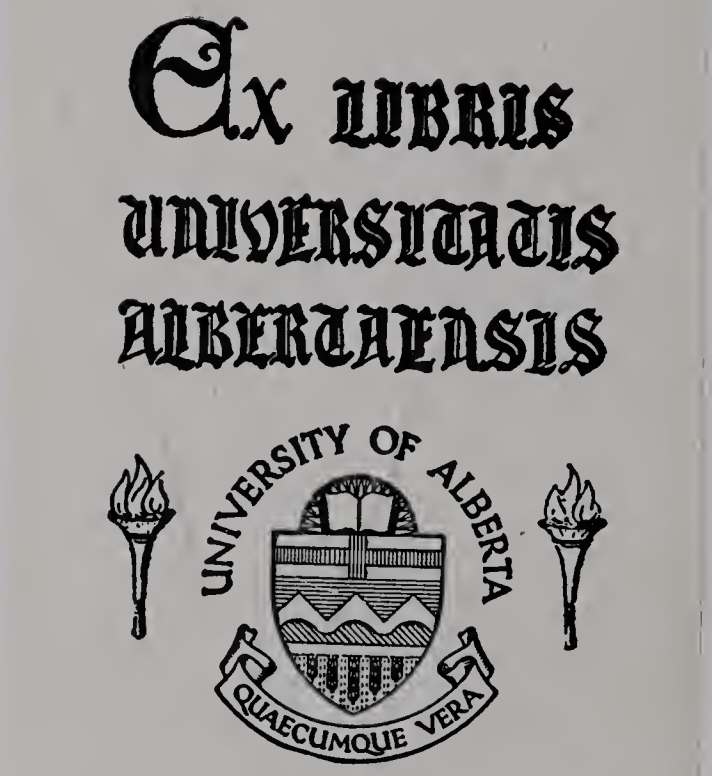
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THE EFFECTS OF STRESS ON ACTIVITY AND AUTONOMIC LABILITY

by

DOUGLAS BARRY MACKAY

A DISSERTATION

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a dissertation entitled "The Effects of Stress on Activity and Autonomic Lability," submitted by Douglas Barry Mackay in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Abstract

In an attempt to obtain a physiological correlate of habituation of activity in an open field, a group of rats was shocked for varying periods. Each rat was then placed in an open field for two 15 min. sessions, and measures of activity, basal resistance level, and defecation were observed. It was expected that the varying lengths of shock would produce varying rates of deceleration of activity as habituation to the open field proceeded, but no differences were apparent in activity nor in defecation. No relationship between activity and BRL could therefore be established. However, BRL was initially higher for the shocked animals, and in addition they returned to their initial arousal level faster than the nonshocked animals, indicating both an overall lower level of arousal and a faster rate of habituation under mildly stressful conditions.

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The purpose of this study was to examine the effects of prolonged noxious stimulation on emotional habituation to a mildly stressful novel situation. The process of habituation was indicated by trends of activity and basal resistance both within and between sessions in an open field. This undertaking involved consideration of three areas: 1) the use of activity in the open field as a measure of emotionality, and the effects of prior stimulation on activity in the field; 2) decrements in activity both within and between sessions as a reflection of habituation to the situation; and 3) the relation between open field activity and basal resistance level while in the field.

It would be useful to pause at this point to briefly consider some terminology. The first experiments using the open field were concerned with examining traits of behavior called emotionality or temperament. These terms referred to characteristics of behavior indicating varying degrees of reactivity, excitability, or responsiveness. Early experimenters studied differences in these characteristics by placing different strains of mice and rats in the field and observing variations in elimination, a measure assumed to reflect emotional reactivity. Later studies have used many other behavioral correlates of autonomic functioning such as activity, latency to leave the first square in the open field, latency to leave a stove pipe, and so on.

More recently, there has been an increasing emphasis on concepts such as arousal and activation. These terms, introduced primarily by Malmo and Duffy, differ from emotionality in the sense that arousal specifies a continuum of physiological functioning ranging from a minimum (sleep or coma) to a maximum (wild excitement). As an internal state, it can be measured by physiological indicators. This study was concerned with observing physiological arousal and relating it to the bodily changes (activity and defecation) associated with reactivity. The relation between emotionality and arousal might be better understood if emotionality is considered as reflecting instability of level of arousal. Perhaps a more cumbersome but more accurate phrase than "emotionality" might be "lability of arousal." Evans & Hunt (1942) considered habituation as an important aspect of emotionality, remarking that "emotionality appears to depend upon the rate at which the observable evidences of emotional excitement are extinguished in a strange situation" (p. 541). In this sense, a more emotional animal may not necessarily possess an overall higher level of arousal, but instead may be less capable of habituation from a high level of arousal to a lower level. When "emotionality" is used in this study, it is being used with this connotation. "Reactivity" refers to the classical definition of emotionality, as indicated by high rates of defecation. "Hab-

ituation" is defined as a decrement of response with repeated exposure to stimulation, and in this case refers to a gradual diminishing of arousal with continued exposure to an initially novel situation.

Activity in the open field

The past twenty years has seen an increasing number of investigations concerned with identifying the behavior patterns associated with reactivity. Emotional reactivity first received experimental attention from Hall (1934), who observed that rats tended to defecate and urinate when placed in a mildly stressful novel situation, the open field. The open field is simply a brightly lit enclosed area, usually about 3 to 7 ft. in diameter or square, which typically elicits an emotional response when rats are placed in it. A certain amount of defecation is usually accompanied by exploratory activity. The open field has frequently been used as a technique for detecting differences in the emotional sensitivity of animals.

Hall's findings instigated a large number of studies dealing with the causes and conditions of individual differences in reactivity. Constitutional factors received subsequent attention from Hall (1938), Billingslea (1940), Farris & Yeakel (1945), and Broadhurst (1957). Attention has more recently shifted to an increasing emphasis on experiential factors (Hall & Whiteman, 1951;

Griffiths & Stringer, 1952; Levine, 1956; Mogenson & Ehrlich, 1958; Denenberg & Karas, 1960; and Denenberg & Smith, 1963). Many of these investigators approached the problem of reactivity by exposing young animals to periods of noxious stimulation or manipulation and observing their reactions in the open field.

Many of the recent studies have employed activity as well as defecation in the open field as a measure of reactivity to stress. Though using only one measure of emotional reactivity, Hall in 1934 remarked that "emotionality is not a thing or faculty... but merely a convenient concept for describing a complex of factors" (p. 400). The validity of this statement has been demonstrated more recently by Willingham (1956), who in a factor analytic study of emotionality using a variety of measures, isolated no less than six factors common to the measures, one of which was the factor of eliminative reactivity described by Hall. A second factor was interpreted by Willingham as being "gross bodily activity" in the field, which supports its frequent use as a measure of reactivity. The implicit justification in many studies for this usage has been that if activity or ambulation is affected by fear, then activity in the open field should provide a valid measure of the degree of fear aroused by the situation.

Effects of prior stimulation on activity

The main raison d'etre of the present study is that there is

a great deal of ambiguity surrounding the use of activity in the open field as a measure of changes in reactivity after prior stimulation. Changes in activity have been interpreted as evidence for either decreased or increased reactivity after stimulation.

Perhaps some of the ambiguity surrounding activity can be better understood by referring to some of the relevant studies. The earliest studies did not observe activity in the open field, but usually in some other measuring device. Billingslea (1940) found that timid or fearful rats (as selected by Hall's open field defecation scores) tended to be more active in an activity wheel after half an hour's adjustment than fearless rats. During the first half hour however, there was a negative correlation between activity and defecation. Using the stabilimeter to measure activity, Evans & Hunt in 1942 confirmed Hall's latter finding that nonemotional animals (again using Hall's criterion) were more active than emotional animals. Increasing distrust of Hall's use of elimination alone as a standard measure of fearfulness was shown by Bindra & Thompson (1953), who found no significant relation between defecation and other measures such as latency to leave a stove-pipe.

In one of the first studies to use activity in the open field as one of the variables, Broadhurst (1957) subjected rats to

periods of noxious stimulation prior to being placed in the open field, and on the basis of decreased defecation in the field, concluded that exposure to noxious stimulation reduces emotionality. Broadhurst did not attach much significance to the results of activity, though he observed a decrement in activity after prior shock.

Levine (1956, 1959a, 1959b) and Denenberg & Karas (1960; Karas & Denenberg, 1961) have consistently obtained results showing that manipulation at very early ages reduces emotionality as measured by increased activity and decreased defecation scores in the open field. Similarly, Meyers (1962) obtained facilitation of exploratory tendencies after infantile stimulation. On the other hand, Montgomery & Monkman (1955) obtained decreased activity in the open field when fear was induced with shock during exploration, but subjecting the animals to fear-inducing stimuli prior to maze exploration had no effect.

Mackay (1963) found no initial differences in activity after prolonged shock, but shocked rats showed faster rates of habituation in the open field as measured by trends of decreasing activity; furthermore, the rate of habituation was found to be curvilinearly related to length of shock. More specifically, both shocked and nonshocked groups showed equal initial activity, but the shocked group thereafter displayed a faster deceleration of

activity, and the trends within the shock group varied curvilinearly with the length of shock. The group undergoing shortest length of shock showed the greatest deceleration, and the group undergoing longest length of shock showed nearly an identical rate of deceleration to that of the short treatment group. However, the group undergoing intermediate length of treatment showed a slower rate of deceleration of activity compared to both the short and long treatment groups. In addition, Sines (1961) showed that rats treated with ECT showed less activity in the field in conjunction with a lower heart rate under subsequent conditions of stress. Such results suggest that reduced activity may reflect reduced rather than increased reactivity.

Furthermore, Snowdon, Bell, & Henderson (1964) observed a decrease in activity in conjunction with decreased heart rate in animals raised in enriched environments, which suggests a decrement in emotional reactivity. This conclusion is confounded, however, by the fact that the animals raised in enriched environments also showed higher defecation, a characteristic usually associated with higher reactivity.

Other studies have drawn conclusions favoring the suggestion that decreased activity indicates higher emotional reactivity. Campbell & Candland (1961) observed decreased activity and increased defecation in the open field when the animals had been subjected

to prior shock, and concluded that these animals were more emotional as a result. Baron (1964) observed a similar decrement in activity with mice after exposure to shock, and drew a similar conclusion.

In summary, the results are generally in agreement but the conclusions are in conflict. The investigators discussed have studied the effects of prior stimulation on reactivity as measured by activity in the open field. Generally, the results have consistently shown a reduction in activity after prior stimulation; however, at this point all agreement ends. Reductions in activity are suggested as evidence either for the hypothesis that prior noxious stimulation increases emotional reactivity or that such stimulation reduces reactivity.

Theoretical explanations

Malmo has been one of the contemporary advocates of the hypothesis that prolonged arousal should increase emotionality or anxiety if the arousal is sufficiently prolonged to reach a certain critical point. As a possible explanation for chronic anxiety and high emotionality in humans, Malmo (1957) suggested that if an organism is subjected to prolonged stress, then the mechanism responsible for inhibition of arousal may undergo a critical change and the organism will no longer be able to efficiently cope with stressful situations. Malmo proposes that chronic anxiety

be considered as a "disease of over-arousal" and notes that pathologically anxious patients react under standard conditions of stimulation with marked physiological patterns of arousal (Malmo & Shagass, 1949; Malmo, Shagass, & Davis, 1950; 1951).

Denenberg and Levine have headed a group favoring an alternative hypothesis that prior stimulation either in infancy or adulthood reduces emotional reactivity to subsequent stress. Walters (1963) has proposed an intermediate position and suggests that small to moderate amounts of noxious stimulation produces sensitization to subsequent stress, whereas prolonged or intense stimulation may increase facilitation of habituation to subsequent stress.

The majority of evidence does not seem to favor the Malmo interpretation if one considers defecation a valid measure of emotionality, but there still exists a considerable degree of ambiguity if other behavioral data are considered. This ambiguity exists largely as a result of inferring physiological states of arousal accompanying emotional disturbance from behavioral data alone without correlating the behavioral data with direct physiological measures of internal states of the organism.

Temporal course of activity

Activity within the open field typically shows a consistent decrease over time within a single session. This effect has been

shown by Campbell & Candland (1961) and Mackay (1963), and the same holds true for exploratory responses to novel stimuli (Adlerstein & Fehrer, 1955; Montgomery, 1951; 1952; and Thompson, 1953). Fowler (1965) comments that this is not surprising, because "with continued exposure to the unfamiliar stimuli, the animal should satiate to these stimuli so that they become less 'novel' and hence less potent elicitors or directors of exploration" (p. 54).

The occurrence of decrements in activity or exploratory responses over sessions, as compared to decrements within sessions, is not as equivocal. Decrements in activity over trials in the open field have been found by Snowdon, Bell, & Henderson (1964) using an inter-trial interval of 24 hr. Studies dealing with exploratory behavior show large decrements between sessions when the inter-trial interval is short (say 10 min.) as Berlyne showed in 1950 and 1955, while a much smaller decrement between sessions has appeared in studies using longer intervals of up to 24 hr. (Butler & Alexander, 1955; Zimbardo & Montgomery, 1957; and Howarth, 1962). No inter-trial interval longer than 24 hr. has been reported, and to determine the effects of longer intervals, the present study used an interval of 5 days. Differences in ability to habituate should be indicated by differences in trends of activity both within and between sessions.

Relations between activity and physiological measures of arousal

Malmo (1958) has proposed that concomitant rather than ante-

cedant measures of drive should be used. In addition to using antecedant deprivation operations and vigor, latency, speed, and frequency of behavioral responses as measures of drive, Malmo argues that psychologists should pay more attention to obtaining direct physiological measures of arousal produced by changes in drive states. Both Malmo (1958) and Duffy (1951, 1962) claim that the important aspect of drives are their arousal or activation dimension, and that the measures of internal arousal provide the most accurate index of the internal states of the organism. Stennet (1957), Bartoshuk (1955), Bélanger & Tetreau (1961), and Hahn, Stern, & Fehr (1964) have all carried out studies relating measures of task performance to physiological measures of arousal, and the evidence generally supports an inverted-U relationship between the two measures; i.e., for any given task, there is an optimum level of arousal accompanied by maximum task performance. If arousal is at a level above or below the optimum level, task performance decreases towards a minimum.

It is proposed in this study that a physiological correlate of activity be obtained as an indication of emotional arousal while the animal is exploring the field. This procedure would help bridge the gap existing between activity and physiological measures as indices of arousal. Examination of the activity data in conjunction with the physiological responses should help resolve the ambiguity surrounding the interpretation of open field activity

and establish the validity of both activity and defecation measures as indices of emotional arousal.

There are a wide variety of available measures of arousal. Physiological measures may include heart rate (HR), skin conductance (GSR and BRL), blood pressure and volume, electromyographic changes (EMG), respiration, rate of oxygen consumption, and the EEG. Belanger & Feldman (1962) have used heart rate during water deprivation as a measure of drive, and Sines (1961) has also used HR as a measure of reactivity. Snowdon, Bell, & Henderson (1964) studied the relationship between open field behavior and heart rate in a comparison of rats raised in enriched and impoverished environments, but unfortunately measured heart rate only in a screened enclosure of roughly the same size as the open field, and observed activity at a later time. The results were nevertheless interesting; the animals raised in an enriched environment showed the signs said by some investigators to be associated with reduced reactivity (increased activity and lower defecation) but these animals also had a higher heart rate than those raised in impoverished environments. These results, conclude the authors, point to the unexpected fact that high heart rate is associated with decreased reactivity.

Somewhat similar results were obtained by Black, Fowler, & Kimbrell (1964), who found marked HR acceleration when animals

were handled for a few minutes at the beginning of each session. The acceleration dissipated in a negatively decelerated fashion over 3 hr., but successive experiences with handling (which is commonly observed to be accompanied by a decrease in defecation) did not reduce the acceleration. Similar effects were observed by Snapper, Ferraro, Schoenfeld, & Locke (1965).

Another physiological measure of habituation has been used by Kaplan (1963). Using basal resistance level (BRL) as a measure of the arousal component of motivation, Kaplan shocked rats several times in a box, then observed their BRL on later days when placed in the box without shock. She observed a gradual progression of the BRL towards greater relaxation both within days and across days as the animals adapted to the situation. These trends correspond to the trends of activity noted earlier.

In summary, the autonomic measures used by the experimenters mentioned above generally show an adaptation of response within sessions and between sessions, but some studies have shown that this process may be much slower than was previously anticipated.

BRL as an autonomic measure

The BRL should be distinguished from the more commonly used GSR. Kimmel & Hill (1961) compared the GSR and BRL as a measure of response to stress, and noted that the conventional GSR is a change in skin conductance to a specific stimulus and is usually

measured immediately after the stimulus is administered. "Typically, the GSR is an abrupt increase in conductance followed by recovery to approximately the original or base level. The measure of change of conductance used in this study (BRL), on the other hand, was a measure of over-all activation-level change and was obtained during periods of no (specific) stimulation" (p. 397). BRL is an indication of the relatively slow dc shifts as opposed to the more transient changes that are characteristic of the GSR. Maulsby & Edelberg (1960) observed that basal resistance varies inversely with dermal temperature and the authors concluded that the effect is probably due to vasoconstriction and thereby directly reflects changes in activity of sympathetic nerve endings, although conductance is also directly affected by skin temperature. Wilcott (1963) has also extensively studied the relationships between environmental temperature and skin resistance.

There is one other important feature of BRL, as opposed to heart rate; BRL can be measured through a grid arrangement in the floor and requires no leads attached to the animal or subdermal electrodes, etc. The mobility of the animal, so important in the open field when activity is being observed, is not hampered as much as if the animal were distracted by leads. It was therefore decided to use BRL as the physiological measure of habituation of arousal in the present investigation.

Present aims and expectations

Habituation of emotional arousal is important to the present study because of its relevance to a previous study by Mackay (1963). As a test of Malmo's hypothesis that prolonged arousal should subsequently reduce inhibition of arousal, Mackay subjected rats to varying lengths of prolonged shock and then measured their rate of habituation to an open field over an hour, the rate of habituation being indicated by the rate of decline of activity. The results showed that variations in length of shock produced variations in rate of habituation, but in the direction opposite to that predicted by Malmo. The trends of activity indicated that ability to habituate was accelerated rather than retarded as a non-montonic function of the length of stress. This conclusion partially supports the hypothesis advocated by Karas & Denenberg (1961), who proposed that emotionality will decrease as the magnitude or duration of the stimulation increases. This hypothesis was later confirmed for mice by Denenberg, Morton, Kline, & Grota (1962). The present study attempted to validate the tentative conclusions drawn by Mackay and the other investigators discussed earlier, especially the conclusions drawn by Snowdon et al. concerning heart rate and activity. The validation was attempted by relating an autonomic measure of habituation to a behavioral measure of habituation, which should help remove some of the

ambiguity of interpreting activity alone as an indicator of emotionality.

The present procedure was essentially the same followed by Mackay (1963). Animals were subjected to three lengths of arousal produced by exposure to intermittent shock for periods ranging from 2 hr. to 10 days. These sessions were then followed by exposure to the open field with simultaneous measures of physiological and behavioral habituation to the situation. Open field behavior was observed again after 5 days, which in turn was followed by post-mortem examination of adrenal gland weights and gastric ulceration. On the basis of current evidence, it was expected that 1) prolonged stress would result in an increased efficiency of habituation; 2) variations in the rate of habituation would be non-monotonically related to length of stress; and 3) the obtained effect would be relatively permanent; i.e., differences in trends would appear over two widely separated sessions.

Method

The main objective was to obtain animals which had been subjected to prolonged periods of arousal. Though the precise method by which this was accomplished was not important, two requirements had to be met; the animals must be kept in a continued state of high physiological arousal, and the method of inducing the arousal must not seriously impair activity in the open field. The latter requirement therefore precluded the use of deprivation or physical exertion as methods for inducing chronic arousal.

With these considerations in mind, it was decided to use prolonged exposure to unavoidable shock for producing differences in arousal, following a procedure used by Mackay (1963). The general design employed in this study was a 2 x 3 factorial design. Each of two groups, the experimental or Shock group and the control or Nonshock group, was divided into three lengths of treatment; 2 hr., 5 days, and 10 days. Each animal was placed in a small box for the duration of the treatment, which, for the Shock group only, involved the administration of unavoidable shock.

Each animal was then placed in an open field and measures of BRL, activity, and defecation were observed. After an interval of five days, this procedure was repeated and was followed by sacrifice and post-mortem weighing of adrenal glands and gastric ulceration counts.

Subjects. A total of 72 male Long-Evans hooded rats were used as subjects, divided equally among each of the six groups. Each

animal was at least 60 days of age when used in the experiment, and was well handled prior to the experiment. During the course of the experiment, the Ss were handled only when being transferred from pieces of apparatus. Food and water was available on an ad lib. schedule throughout the experiment except during exposure to the open field.

Apparatus. Each animal was placed in a specially constructed box which, while permitting almost normal horizontal movement, reduced vertical movements to a minimum. Avoidance reactions to the shock, administered through a grid floor, were thus nearly eliminated. The confinement boxes were constructed of 3/8 in. plexiglass in units of three so that 3 Ss could be shocked simultaneously. The boxes were made nearly identical to those used by Mackay (1963) with inside dimensions measuring 2 in. by 2.5 in. by 7 in. The bars in the floor were 1/8 in. brass rods 5/8 in. apart. Food and water were readily available to each S through holes in the front of each box.

Shock was administered through a matched impedance circuit from a power supply consisting of a Variac transformer driving a step-up transformer (Hammond 270Z) which raised the voltage by a factor of 5. Based on the results of preliminary work, the Variac was set at 35 volts. Shock was delivered through a 220 kilohm resistor, and was triggered by a Gerbrands film strip timer.

The open field was 4 ft. square, with 12 in. panels set diagonally in each corner to eliminate right angles. The walls were painted flat white wood 18 in. high, with white cloth hung above the walls.

Activity was measured by a photocell arrangement around the perimeter of the field. The beams of light divided the field into 12 in. squares. Activity was recorded by a counter which was activated when an animal crossed a photocell beam. Each photocell unit was connected in parallel with a counter which printed the cumulative activity when a Gerbrands film strip timer tripped the printer once a minute. Flashlights converted to 6 VDC served as the sources of illumination for the photocells.

A 150 watt bulb in an aluminized reflector was suspended 30 in. over the center of the field. Behind the white drapes on opposite sides of the field were two 8 in. speakers through which was projected 80 db of white noise, measured by a General Radio sound level meter placed in the center of the field.

The floor of the field was of grid construction using 1/8 in. brass rods running diagonally across the field. Each rod was 1/2 in. apart, which was considered sufficient to allow defecation to fall through. Each adjacent rod was of a different polarity, and was supported at 6 in. intervals along its length by brass strips under the rods and running at right angles to the rods.

A sketch of the grid layout can be seen in Appendix A. The entire grid was supported along its edges in a rigid 2 x 4 wooden frame, which in turn was raised 2 ft. from the floor on 4 x 4 legs. Raising the grid from the floor achieved two purposes; it minimized the problem of defecation accumulating under the grid and possibly distracting the Ss, especially in the corners and along the walls. This arrangement also facilitated the counting of boli.

As each adjacent bar in the grid was of opposite polarity, the resistance of the animal could be measured if any two feet were touching bars of opposite polarity. This method of measuring resistance was first used by Kaplan (1963) in a Skinner box, but was here expanded for use in the open field.

BRL was measured through the grid by means of a modified Wheatstone bridge circuit. A stable source of 110 VAC was fed from a voltage regulator to a DC power supply producing 500 VDC into the bridge. The bridge in turn was connected to the grid and also to a chopped DC amplifier feeding into a large scale voltmeter set at the 2.5 volt scale. Readings were taken directly from the meter and converted by means of the subsequently obtained calibration graph into resistance units for analysis. The whole system, shown in block form in Appendix B, supplied 57 microamps to the grid. A schematic diagram of the bridge, modified from a design supplied by Kaplan (personal communication) can be seen in Appendix C.

Procedure. After arrival at the laboratory, each animal was caged individually in ordinary rack cages for at least a week to permit familiarization with diet and environmental changes. Each animal was then weighed and randomly assigned to either the Shock or Nonshock groups for periods of 2 hr., 5 days, or 10 days. There was a sufficient number of confinement boxes to permit running 3 animals from each of the Shock and Nonshock groups simultaneously. The sole variable between the Shock and Nonshock groups was that the Shock group received shock pulses varying randomly from 0.5 to 1.5 sec. in duration and which were delivered at random intervals averaging one minute for the duration of the treatment.

After completing their treatment, each animal was returned to its rack cage for 24 hr. At the end of this period, each rat was placed in the open field for 15 min. and measures of activity, BRL, and defecation were observed. Activity was counted automatically by the print-out counter once a minute, and BRL was observed by recording the lowest voltage indicated by the meter within a 10 sec. period once every minute. This procedure reduced the possibility of recording only a movement artifact. Defecation was recorded by counting the total number of boli excreted during the 15 min. in the field. Each animal was then weighed.

After returning to their rack cages for 5 days, the animals

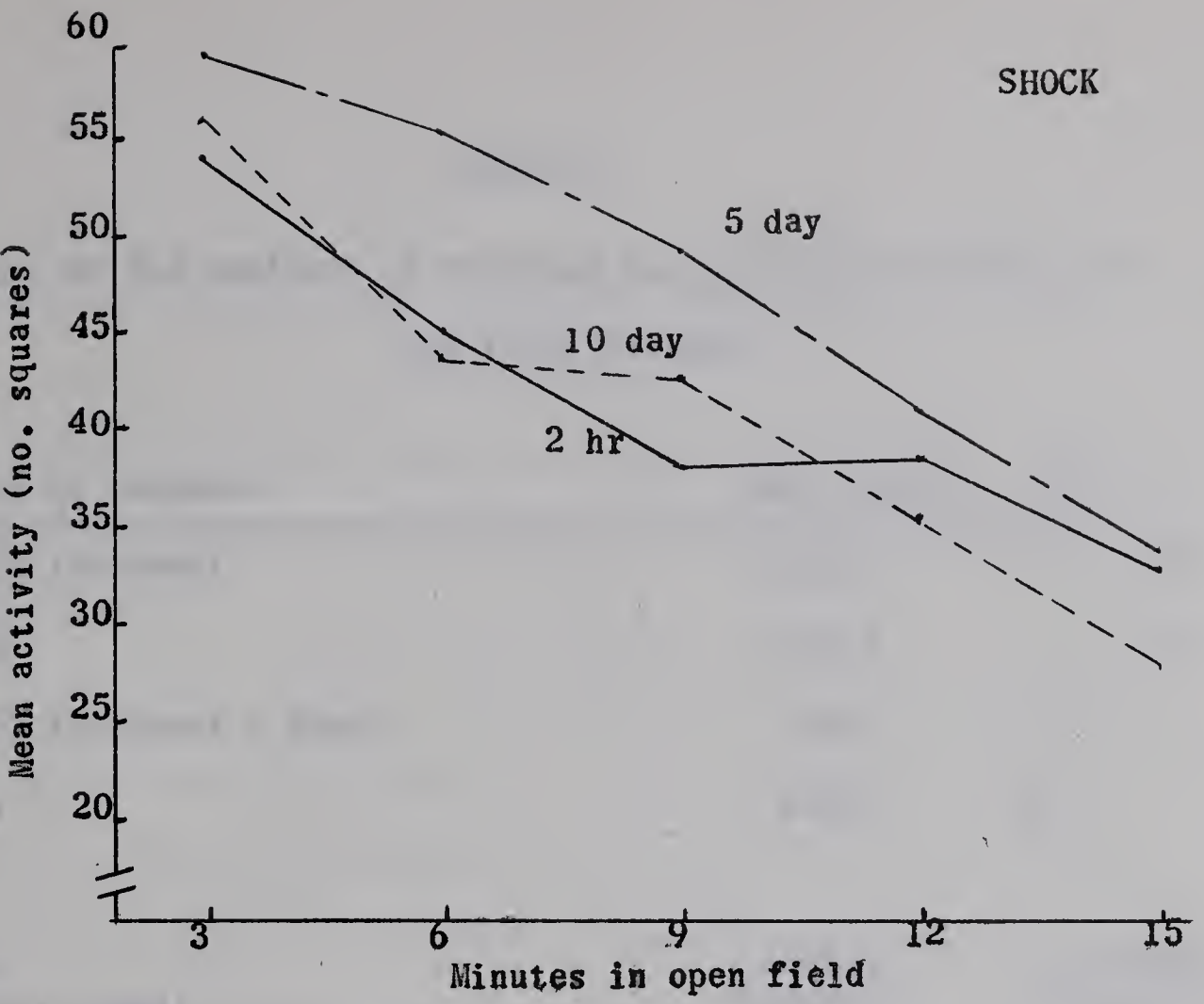
were again placed in the open field for 15 min., and the observations were repeated. Each rat then received a final weighing, was sacrificed using an overdose of sodium pentobarbital, and post-mortem examination of adrenal glands and gastric ulceration was carried out. The glands and stomach were removed and the glands were carefully weighed on an analytical balance accurate to 1 milligram. The stomachs were examined for ulcers by opening each stomach along the outer curve from end to end, then laid on a piece of plastic foam and stretched in place with pins. Examination was then made under an illuminated magnifying glass for ulcers and the total number recorded.

Results

Analysis of the data was carried out in five main stages. Trend analyses were performed on each of the two sets of activity observations and on each of the two sets of BRL data. The fifth stage consisted of analyses of variance on the observations of weight, defecation, ulceration, and adrenal weights. The analyses of variance were patterned on the procedures described by Edwards (1960) and the coefficients of orthogonal polynomials for the trend analyses were assigned according to a method described by Winer (1962). To fulfill one of the underlying assumptions of trend analysis of variance, it was assumed for purposes of analysis that the intervals in length of treatment between groups were equal. The length of treatment variable (2 hr., 5 day, and 10 day) was assumed to be equally divided by considering the 2 hr. group as representing 0 day, thus allowing equal intervals of 5 days between groups.

Activity

The results of the first session of open field activity for all groups are shown in Fig. 1. A summary of the analysis is given in Table 1, and the group means and sums of squares appear in Appendix D (summaries of all the following results may be found in their respective Appendices). It can be seen from the trends in Fig. 1 and the results of the analysis shown in Table 1 that none of the groups showed significant differences in trends of activity in the first session. The only trend of significance was a linear



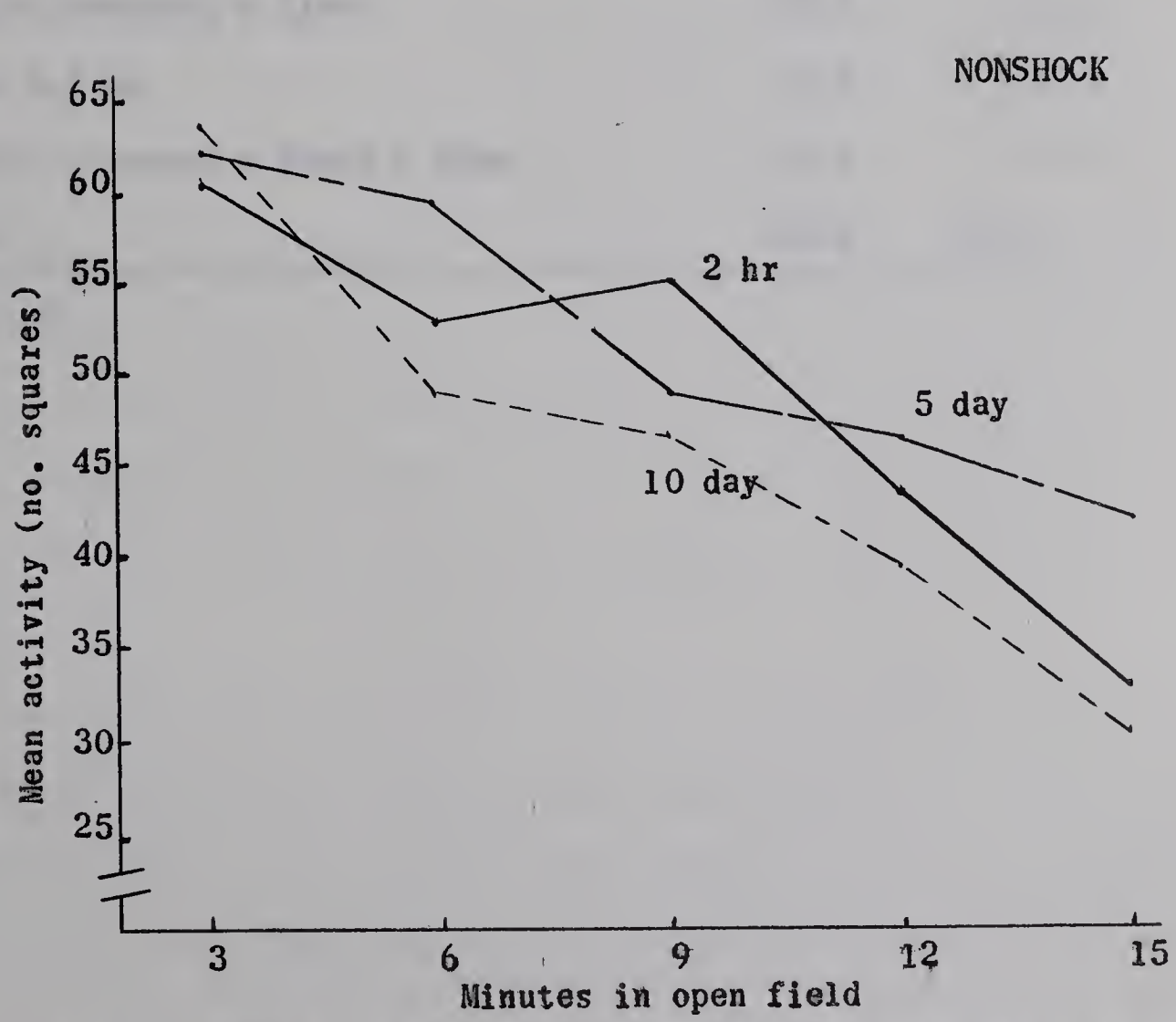


Fig. 1. Mean activity of all groups in the open field during the first session.

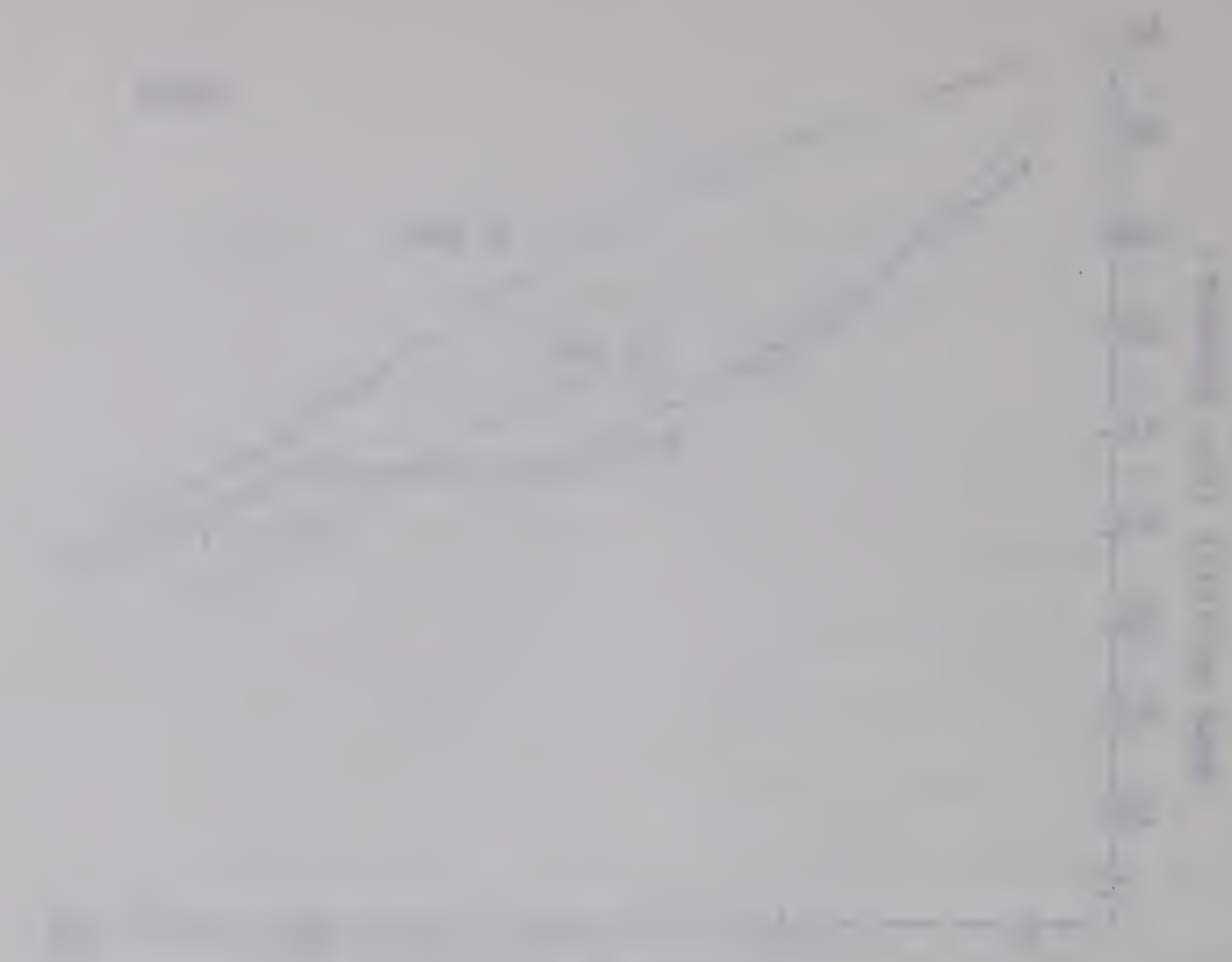




Table 1.

Summary of the analysis of variance for open field activity in the first session.

Source of variance	Mean square	df	F
Length treatment	1206.9	2	1.36
Shock	1960.0	1	2.21
Length treatment x Shock	126.6	2	<1
Error	886.5	66	
Time	6567.8	4	37.8**
(linear trend)	(26004.1)	(1)	(149.7)**
Length treatment x Time	88.8	8	<1
Shock x Time	15.9	4	<1
Length treatment x Shock x Time	131.9	8	<1
Error	173.7	264	

**p < .01

decrease in activity over all groups, accounting for 99% of the Time variance. Since none of the interactions with Time were significant, it appears that neither shock nor length of treatment exerted any differential effect on the trends of activity, and that all groups showed identical decrements in activity.

In the second session, the results of which are shown in Fig. 2, a highly significant overall decrease in activity was observed similar to that which occurred in the first session. A summary of the analysis appears in Table 2. In addition to the overall linear trend, a significant quadratic component was evident. By inspection of Fig. 2, it can be seen that the quadratic component is confined to the Shock group, indicating that the decrease in activity for this group was curvilinearly decelerated.

Several trend components of the Shock x Time interaction were significant, though the total interaction itself was not. Trend analysis showed that the differences between Shock and Nonshock trends contained a significant linear and quadratic component, accounting for 50% and 44% of the interaction variance respectively.

In summary the results for activity over both sessions were generally inconclusive. Neither shock nor length of treatment were effective factors for producing differences in group means, though shock did produce some trend differences in the second session.

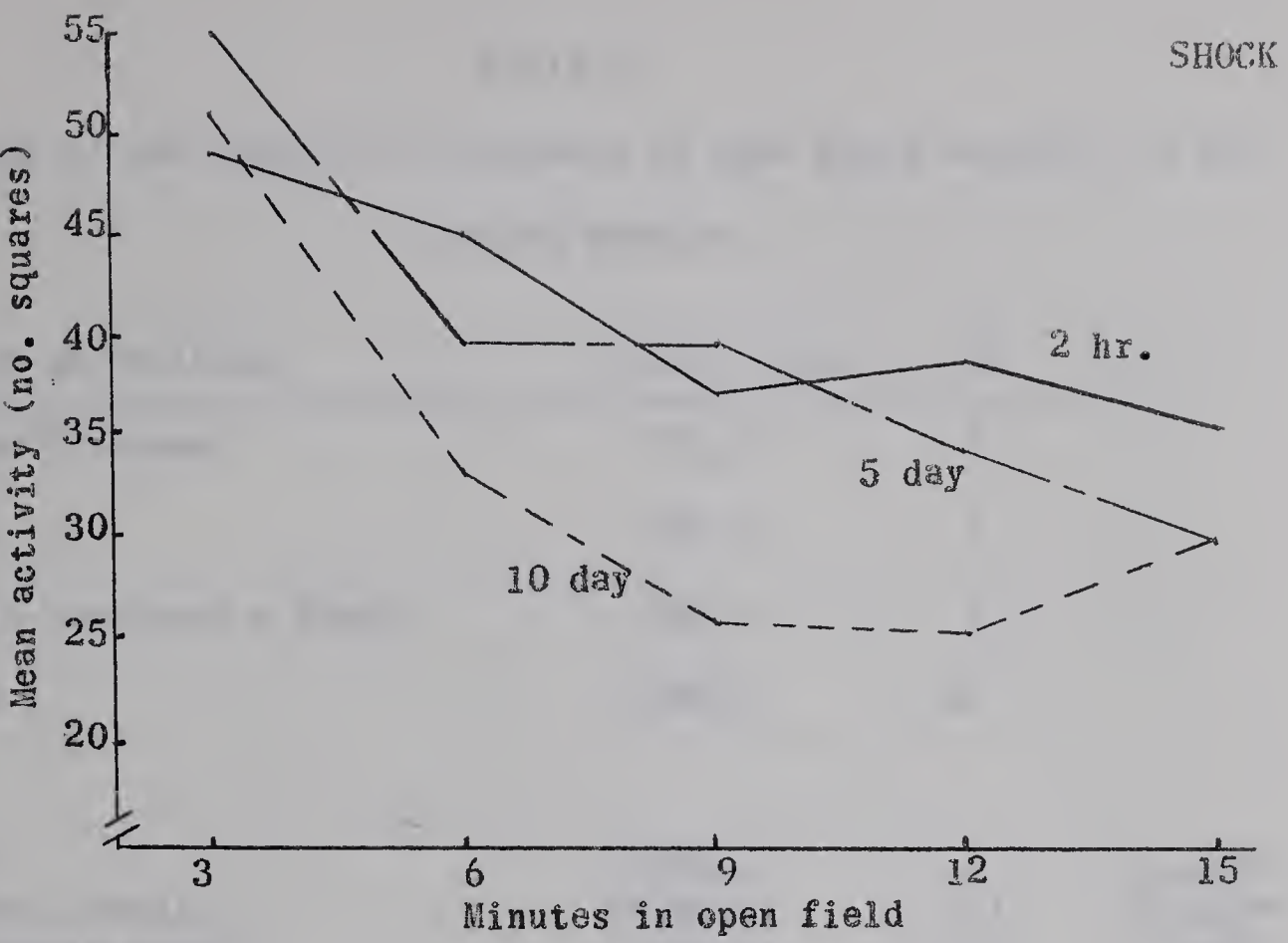


Fig. 2. Mean activity of all groups in the open field during the second session.

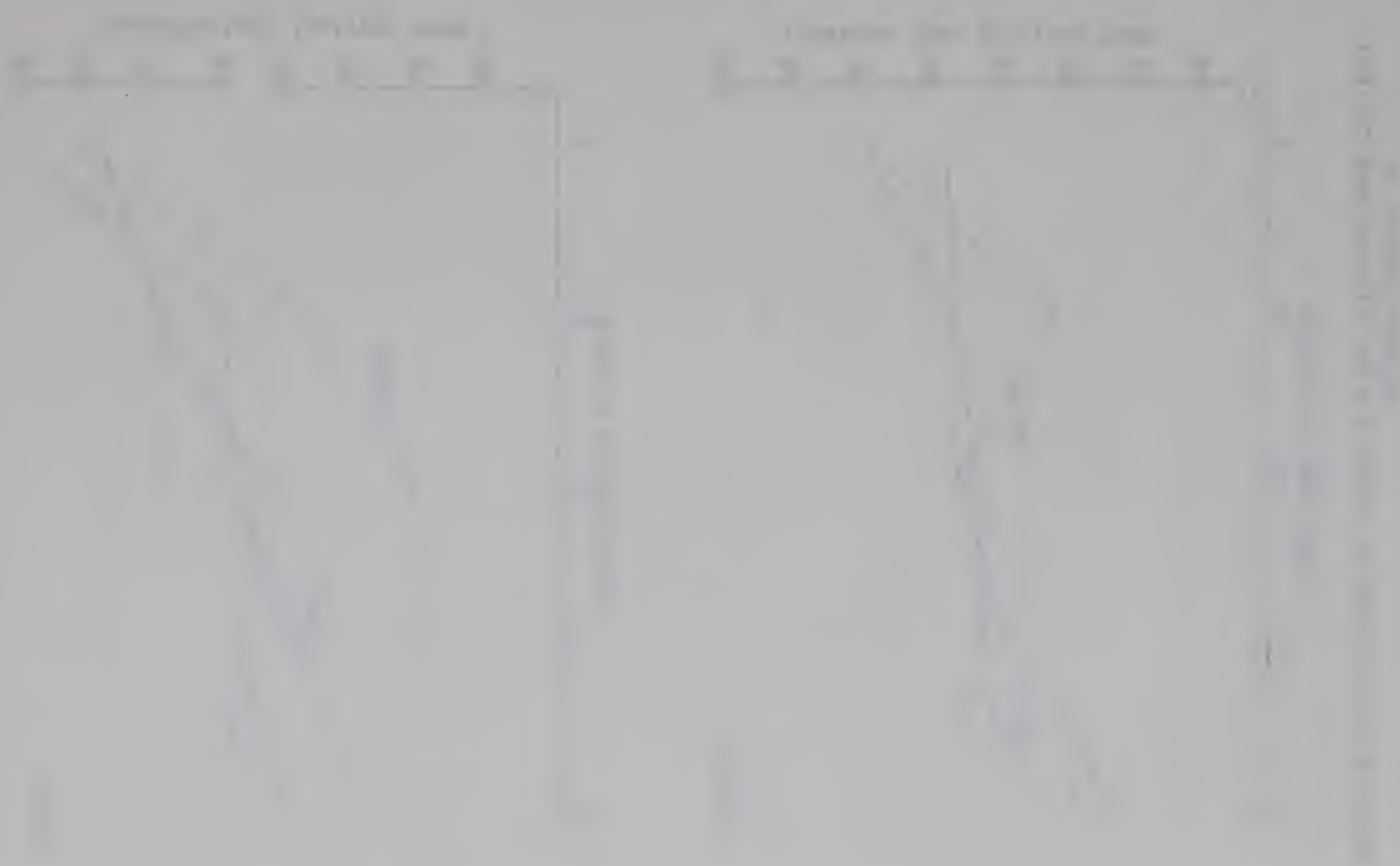


Table 2.

Summary of the analysis of variance of open field activity in the second session.

Source of variance	Mean square	df	F
Length Treatment	791.6	2	<1
Shock	304.4	1	<1
Length Treatment x Shock	226.5	2	<1
Error	1105.3	66	
Time	2720.4	4	16.17**
(linear trend)	(9388.9)	(1)	(55.82)**
(quadratic trend)	(948.9)	(1)	(5.64)*
Length treatment x Time	228.9	8	1.36
Shock x Time	381.2	4	2.27
(differences in linear trend)	(768.8)	(1)	(4.57)*
(" in quadratic trend)	(663.8)	(1)	(3.94)*
Length Treatment x Shock x Time	32.1	8	<1
Error	168.2	264	

**p < .01
*p < .05

Intrasession decrements in activity were clearly evident, and a drop in mean activity between sessions was also evident. The mean total decrease in the second session was 12 squares of activity.

BRL

Before considering the BRL results, a remark should first be made concerning the statistical treatment of the data. The BRL observations consisted initially of readings taken from a voltmeter connected to a Wheatstone bridge circuit. The data was therefore originally in the form of volts, not ohms. The voltage readings were converted to resistances after completion of the experiment by means of a graph relating voltage to resistance. The calibration graph (see Appendix) was obtained by placing known resistances across the grid and observing the corresponding voltages on the meter. It was found that the relationship between voltage and resistance was not linear but was rather a power function. This fact created a problem with the not uncommon occurrence in the data of very high resistances produced by movement artifacts or other similar poor contact with the grid. These high resistances, after conversion from the calibration graph, resulted in greatly exaggerated scores and generally distorted the trends established by the recordings made during the more frequent periods of good contact.

Several transformations of the resistance data were then con-

sidered, such as log resistance (Haggard, 1941) and its reciprocal, log conductance, in an attempt to achieve some linearity of the data. It became apparent, however, that such transformations would not become necessary; the data already existed in linear form with the original voltage readings. It was therefore decided to use the original voltage readings which already incorporated a linear transformation. Since resistance rose exponentially, very large increases in resistance are compressed by this transformation into more linear increases in voltage.

The results of the trends of BRL for all groups in the first session are shown in Fig. 3, and a summary of the analysis is shown in Table 3. In the first session, BRL did not show any overall consistent increase in resistance over time to correspond with the intrasession decrements observed with activity. However, the Shock x Time interaction was significant, and the differences in trends of the Shock and Nonshock can be seen in Fig. 3. Both Shock and Nonshock groups showed nearly equal resistance in the first 3 min., then both groups diverged on different trends. The trends of resistance in the Shock group tended to rise throughout the session after an initial sharp drop, while those of the Nonshock group underwent a fairly consistent decline, except for the final 3 min. when the trend was reversed and resistance rose slightly. The opposing trends seen in this interaction probably

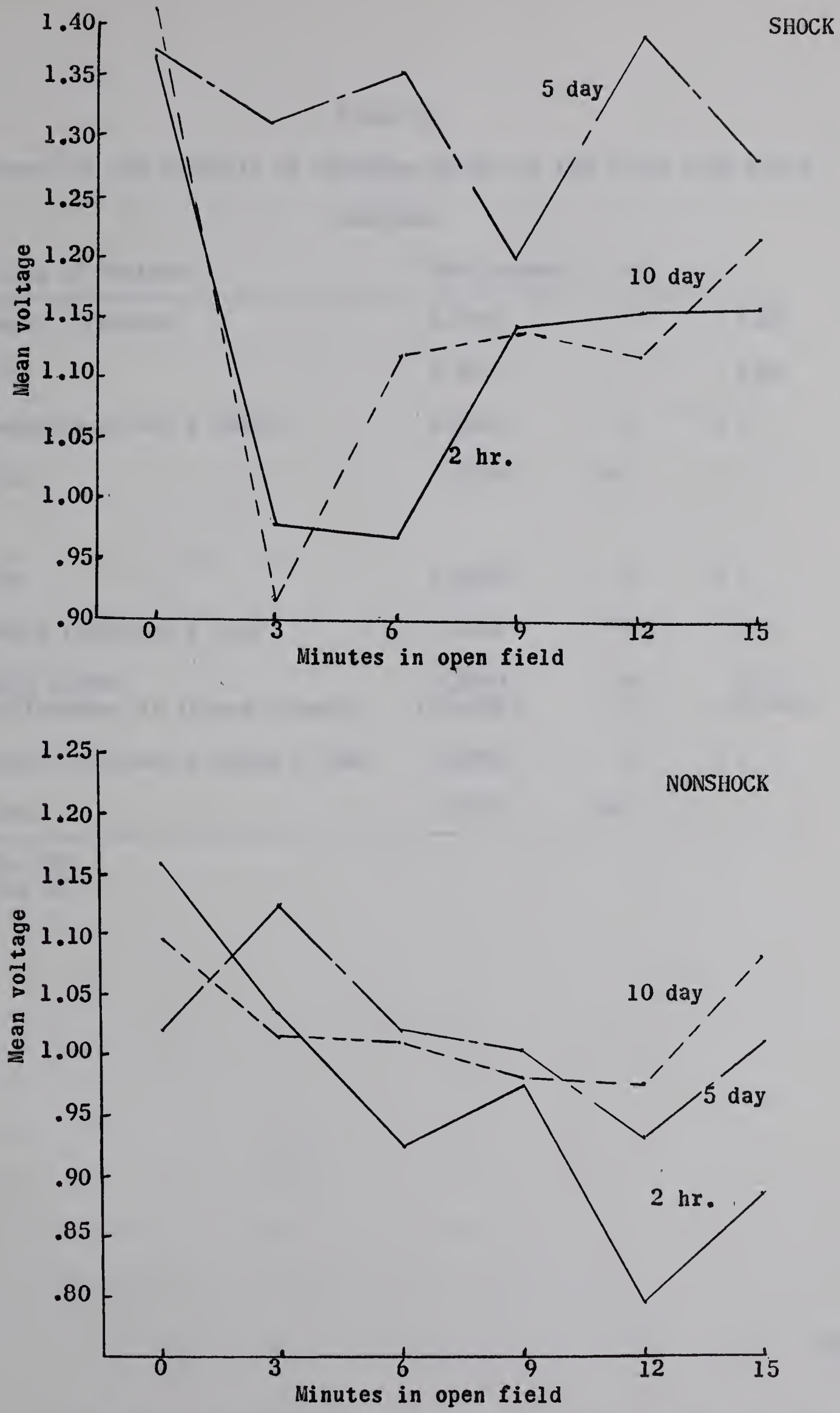


Fig. 3. Mean BRL for all groups (Shock, top; Nonshock, bottom) in the open field during the first session. (Resistance increases with voltage).

Table 3.

Summary of the analysis of variance of BRL in the first open field session.

Source of variance	Mean square	df	F
Length Treatment	0.7767	2	1.33
Shock	0.9713	1	1.68
Length Treatment x Shock	0.3001	2	< 1
Error	0.5764	66	
Time	0.0249	4	< 1
Length treatment x Time	0.0806	8	1.02
Shock x Time	0.2183	4	2.75*
(differences in linear trends)	(0.6254)	(1)	(7.90)**
Length treatment x Shock x Time	0.0431	8	< 1
Error	0.0793	264	

**$p < .01$
*$p < .05$

account for the absence of an overall decreasing trend in BRL similar to the activity trends. (It should be noted here that the first point (0) in Fig. 3 and Fig. 4 was not included in the analyses of variance performed on the remainder of points (3, 6, 9, 12, and 15 min). This point was omitted to make the bases for comparison between activity and BRL as nearly identical as possible. The observation in question (0) was taken during the first 10 sec. in the field. The sharp drop evident in the Shock group during the first 3 min. was therefore not considered in the analyses. The remaining points are means based on medians of the three observations taken at 1 min. intervals during the 3 min. prior to the time indicated by the point.) The Shock group thus shows a decrease in physiological arousal after an initial increase coinciding with a decrease of activity, while the Nonshock group actually shows an increase in arousal over time corresponding with a decrease in activity. The difference in linear trends for these two groups was significant at the 1% level of confidence, representing 72% of the variance of the interaction.

The results of the changes in BRL for the second session are shown in Fig. 4 and a summary of the analysis is given in Table 4. BRL for this session shows no significant Shock x Time interaction. Though the Shock x Time interaction was not significant in the second session, the interactions between Shock and Nonshock groups

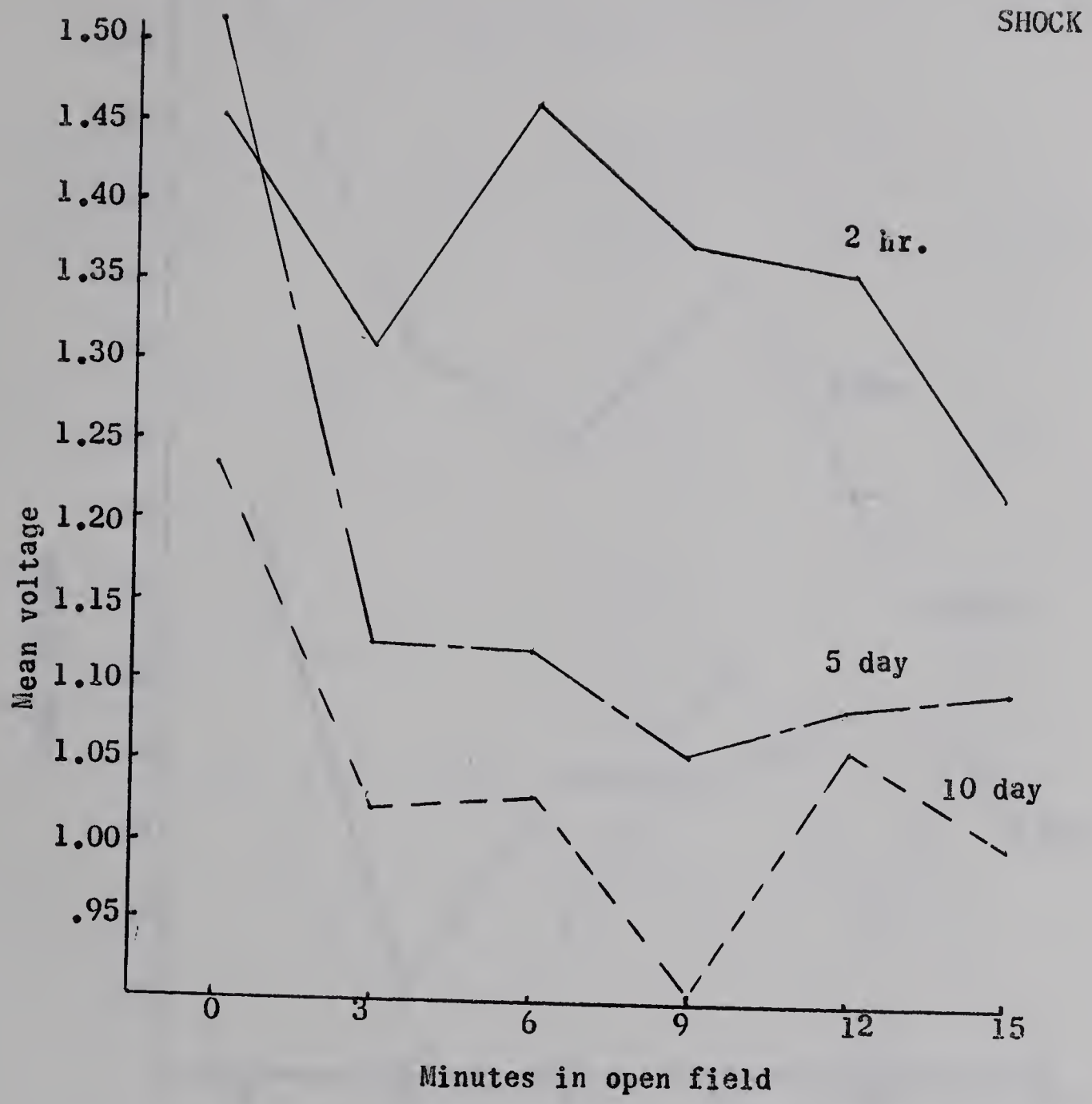


Fig. 4a. Mean BRL for the Shock group in the open field during the second session. (Resistance increases with voltage.)

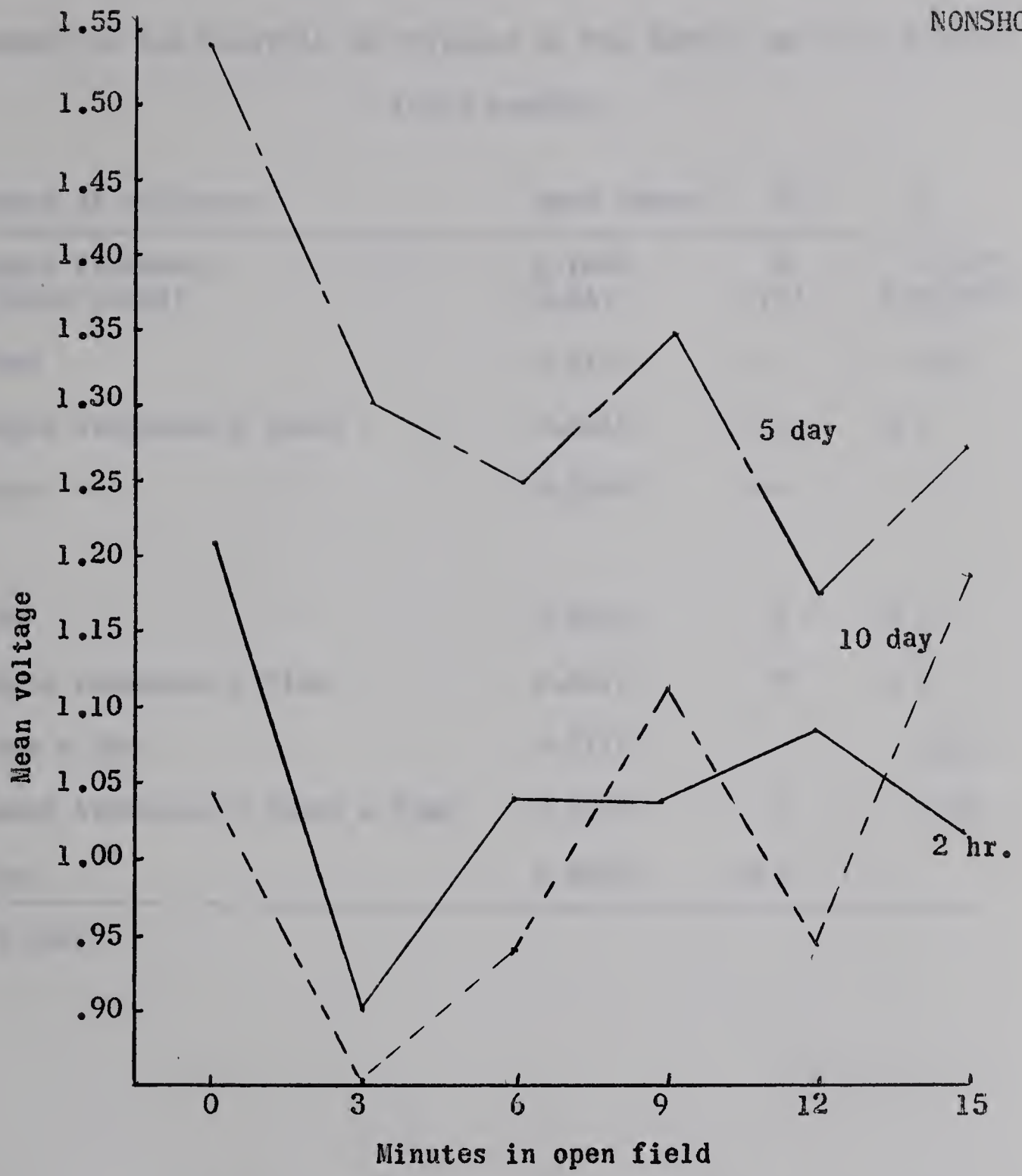


Fig. 4b. Mean BRL for the Nonshock group in the open field during the second session.

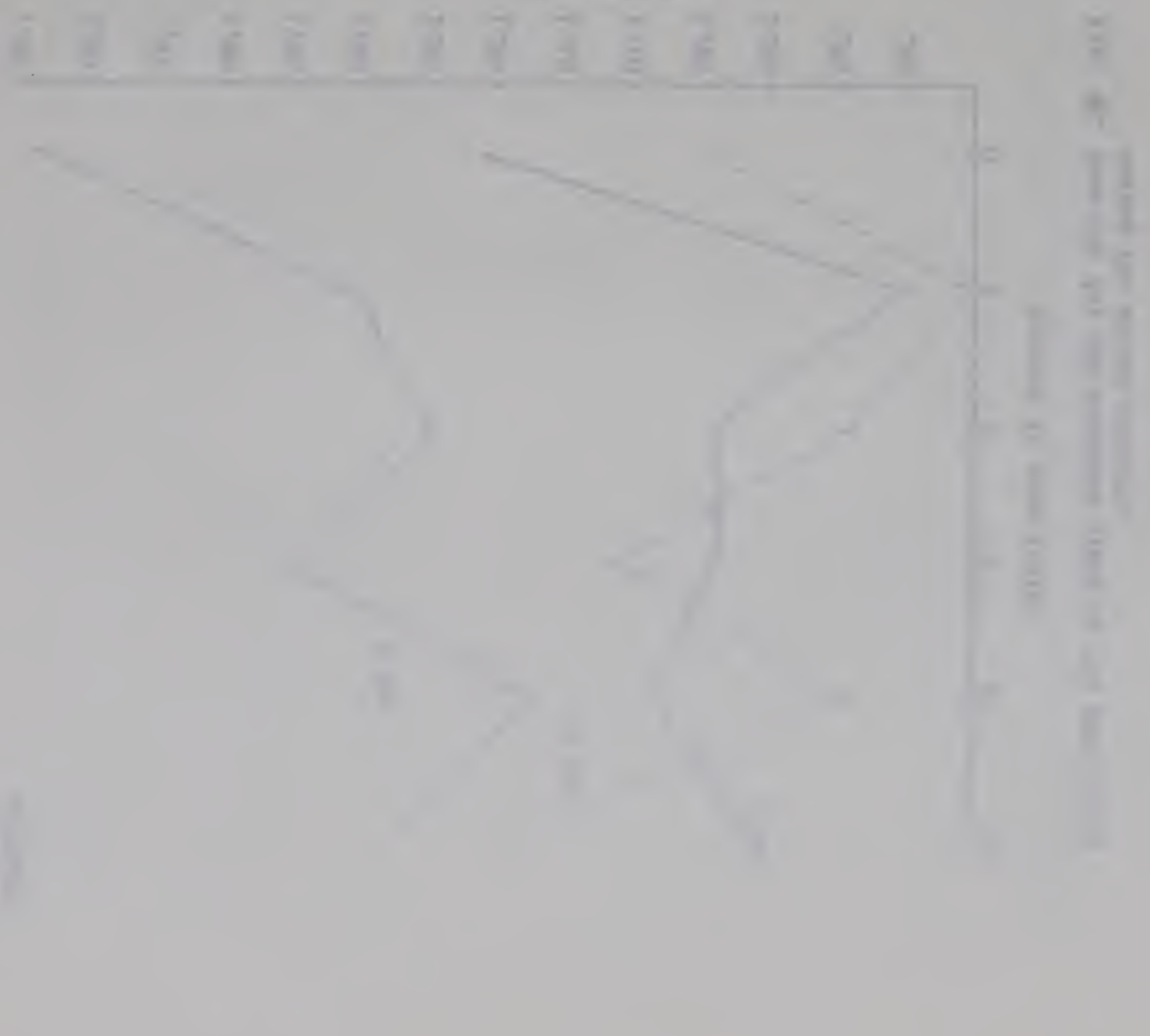


Table 4.

Summary of the analysis of variance of BRL during the second open field session.

Source of variance	Mean square	df	F
Length Treatment	3.1669	2	6.01**
(linear trend)	(5.54)	(1)	(10.51)**
Shock	0.1765	1	3.35
Length treatment x Shock	0.0815	2	< 1
Error	0.5269	66	
Time	0.0421	4	< 1
Length treatment x Time	0.0617	8	< 1
Shock x Time	0.1771	4	1.82
Length treatment x Shock x Time	0.1549	8	1.59
Error	0.0973	264	

**p < .01

for both sessions are shown in Fig. 5, as some interesting differences in BRL between sessions can be seen. In the first session, BRL for the two groups was initially nearly identical and then diverged; in the second session, the Shock and Nonshock groups show wide initial differences which disappear later in the session. The Shock group maintains a higher initial resistance level in the second session than the Nonshock group.

Length of treatment in the second session was also a significant variable, unlike the first session. The differences in mean resistance between the 2 hr., 5 day, and 10 day groups combined over the Shock and Nonshock conditions are shown in Fig. 6. As length of treatment increased, resistance decreased. The 10 day group showed the least resistance, and resistance increases in the 5 day group and reaches a peak in the 2 hr. group. The linear component of this trend accounted for 88% of the variance and was significant. It is somewhat puzzling that this variable was not effective in producing these differences in the first session. It is possible that these differences did occur in the first session but were obscured by the Shock x Time interaction.

In summary, the results of the activity and BRL data indicated that differences in resistance were not accompanied by corresponding differences in activity; moreover, the differences in resistance

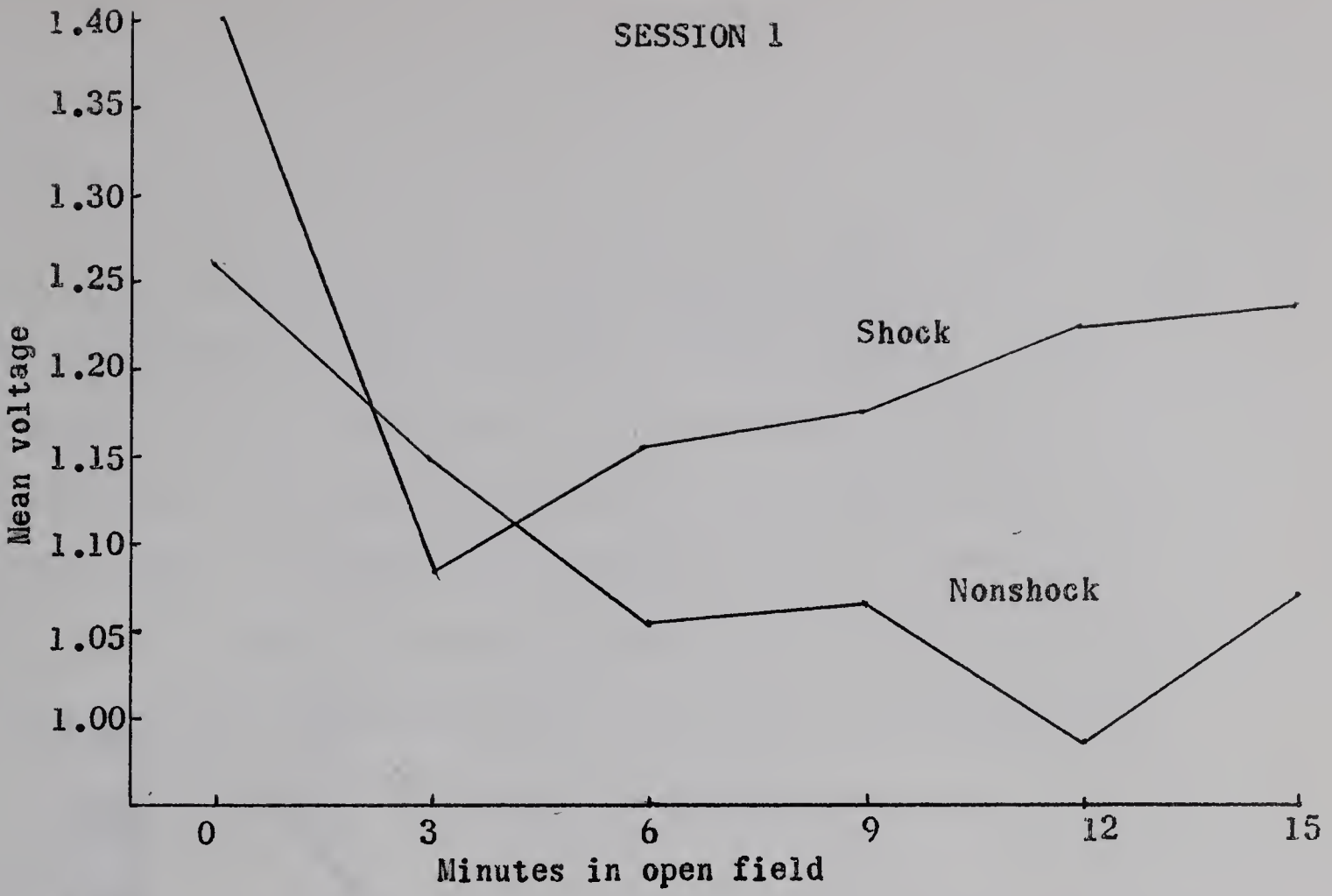


Fig. 5. Mean BRL for Shock and Nonshock groups during session 1 (top) and session 2 (bottom).



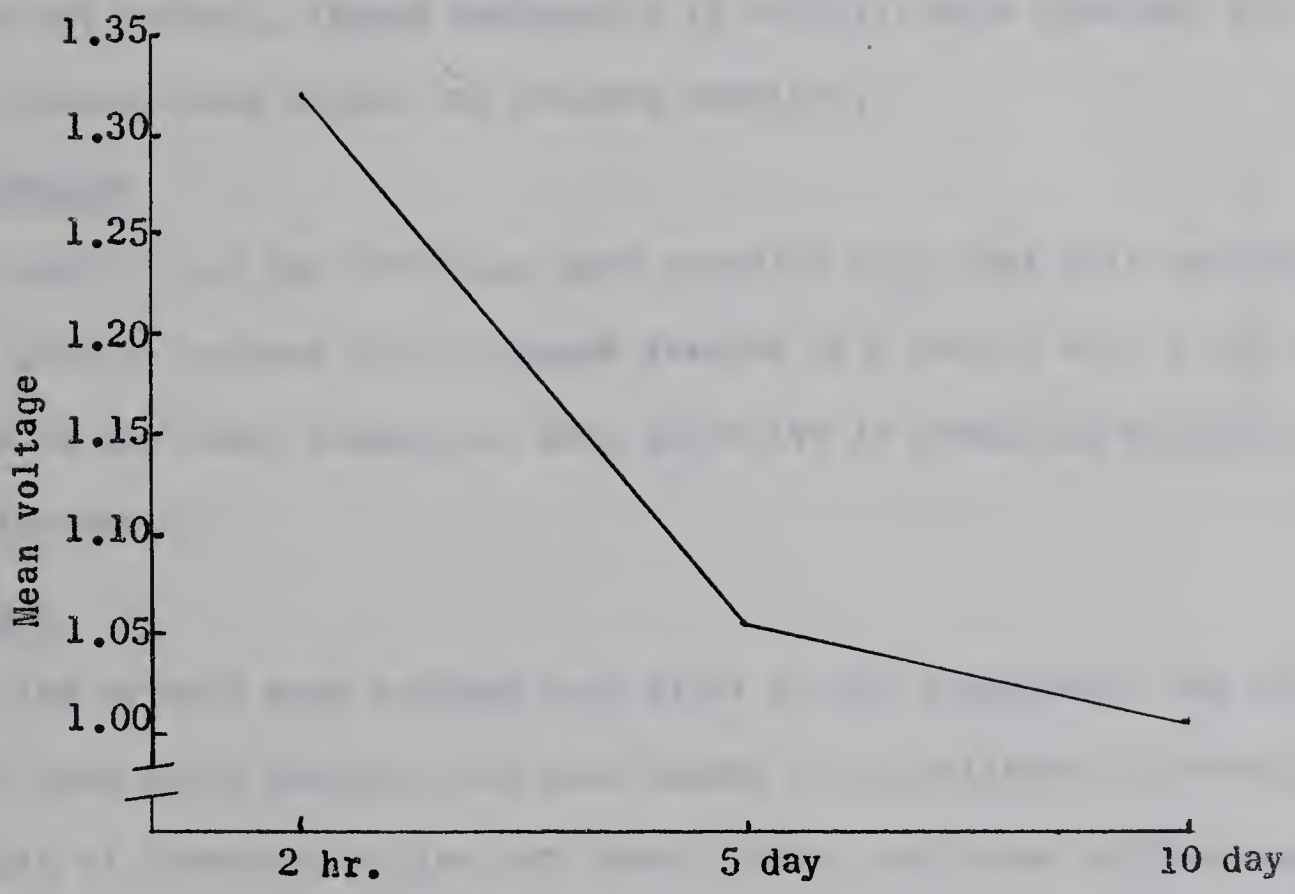


Fig. 6. Mean BRL of combined 2 hr., 5 day, and 10 day groups during the second open field session.

level tended to disappear over sessions, though differences in resistance level between groups subjected to varying lengths of treatment became evident in the second session. Resistance level of the shocked animals was higher than the nonshocked animals in the first session, though this difference disappeared in the second session. Differences in trends of activity between Shock and Nonshock groups were not evident, though decrements in activity were apparent for all groups, both within and between sessions.

Defecation

Analysis of the defcation data revealed only that this activity was greatly reduced in the second session ($F = 20.01$, $df = 1$ and 66). None of the other conditions were effective in producing significant differences.

Weight

The animals were weighed just prior to the experiment, and after each open field session. The data showed two significant interactions, Length of Treatment x Time and Shock x Time, and these differences can be seen in Fig. 7. Table 5 shows the results of the analysis of variance. All groups showed a drop in weight after completion of their treatment and the first open field session, which is followed by great increases in weight, especially for the 5 day and 10 day groups, while the 2 hr. group shows little increase. However, the large differences in initial weights between all groups is disturbing.

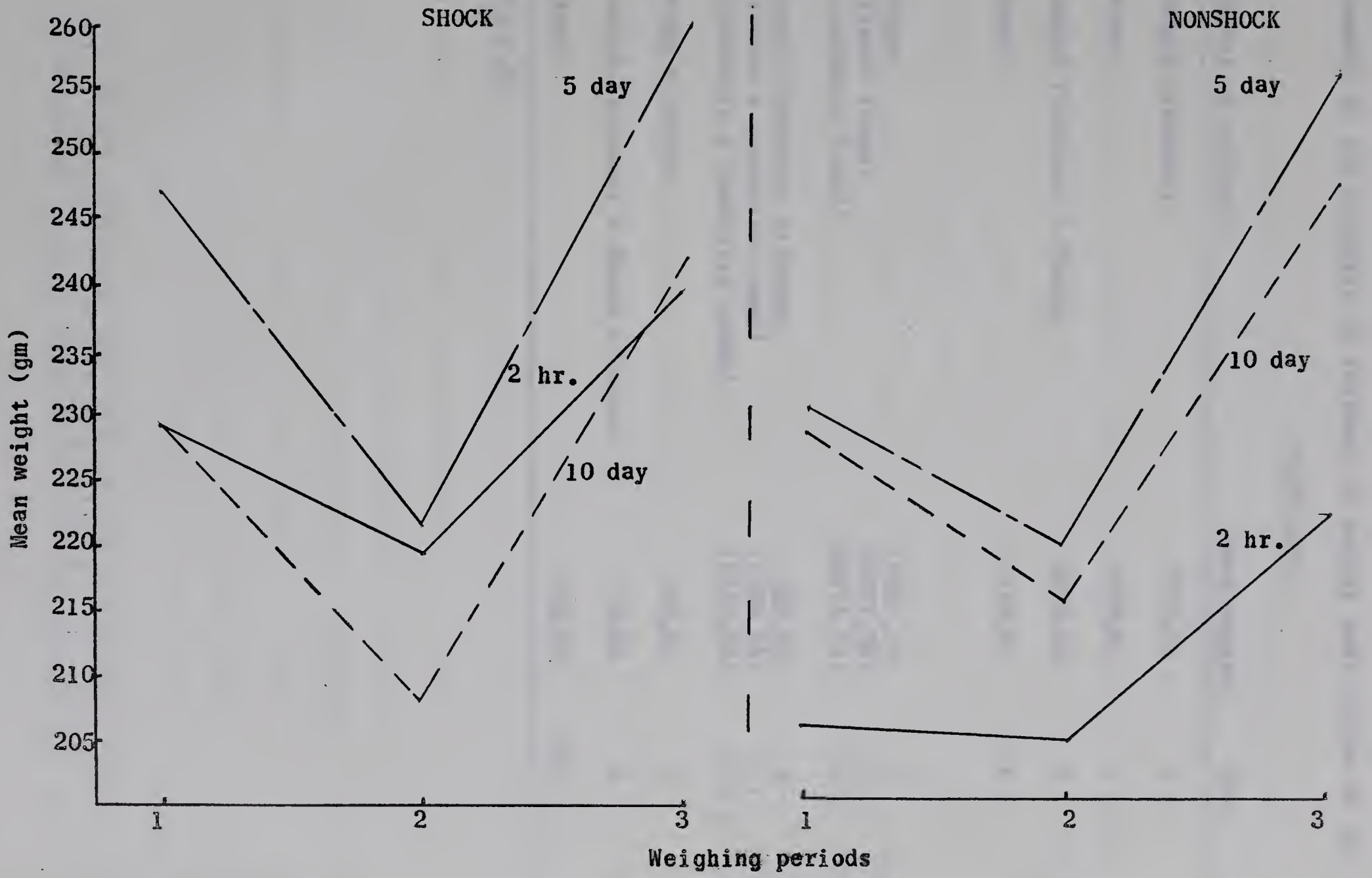


Fig. 7. Mean weights of all groups throughout the experiment. (1 - Preshock; 2 - open field 1; 3 - open field session 2.)



Table 5.

Summary of the analysis of variance of weight over stages of the experiment.

Source of variance	Mean square	df	F
Length Treatment	5757.76	2	1.52
Shock	2896.67	1	<1
Length Treatment x Shock	2372.65	2	<1
Error	3779.61	66	
Stages	15676.14	2	115.75**
(linear trend)	(8977.56)	(1)	(66.29)**
(quadratic trend)	(22374.72)	(1)	(165.21)**
Length Treatment x Stages	726.08	4	5.36**
(linear x quadratic trend)	(1378.13)	(1)	(10.18)**
(quadratic x quadratic trend)	(1355.00)	(1)	(10.01)**
Shock x Stages	460.01	2	3.40**
Length Treatment x Shock x Stages	59.85	4	<1
Error	135.43	132	

**p < .01

Though the largest difference between groups represents a mean weight of only 22 grams, it was hoped that the groups would be more homogenous in size.

The Length of Treatment x Time interaction had both a significant linear x quadratic component and a significant quadratic x quadratic component. This indicated that: 1) changes in weight throughout the stages in procedure followed a curvilinear form, a fact which can easily be seen by inspection of the graph; 2) the weights of the 2 hr., 5 day, and 10 day groups generally increased with length of treatment, but this increase was curvilinear in form. That is, the 10 day group was heavier than the 2 hr. group, but it was also slightly lighter than the 5 day group.

The Shock x Time interection was significant as well, but differences in trends just failed to reach significance. Inspection of the graph confirms that the Shock and Nonshock groups differed only in means, and that the trends were practically parallel.

With significant differences in weight appearing in the 2 hr., 5 day, and 10 day groups, and similar group differences in second session BRL also evident, it was suspected that these differences in BRL were produced by differences in weight between these groups. To test this possibility, rank correlations were determined for each group between each post-open field session weight and the initial BRL recordings in each session. None of the correlations were

significant, ranging from ρ = +.476 to ρ = -.503 (n = 12). Rank correlations between weight and BRL were also determined when the Ss were grouped according to length of treatment (corresponding with the significant BRL interactions) and these also were not significant, the ρ's ranging from +.372 to -.222 (n = 24). The differences in weight therefore did not appear to significantly affect the initial BRL recordings.

Were the differences in weight a function of treatment? The fact that differences in weight appeared even prior to the beginning of the experiment, as shown in Fig. 7, argues against this explanation and supports the hypothesis that the differences are a result of systematic selection error when the Ss were assigned to groups. During the study, 6 rats of a certain group were run at a time. These were followed by 6 more rats from another group, and this rotation of groups was continued throughout the experiment. It is therefore difficult to imagine how the groups differed in size through systematic assignment error (for example, differences in litter sizes) and an alternative explanation is that the differences are the result of a Type I error. In addition, the size differences did not appear to affect activity, as there were no differences in activity between groups. It was possible however, that when activity was expressed in terms of weight, then differences between the groups might well appear. To check this possibility, total activity for each S for each

open field session was divided by the weight of each S for that session, and an analysis of variance was performed on the resulting ratios. An analysis of variance was done on each of the sessions, and none of the differences were significant. The possibility of a relationship between activity and weight thus seems ruled out.

Ulceration

There was a fairly low incidence of gastric ulceration in all animals. A total of 10 rats in the Shock group (2 hr., n = 2; 5 day, n = 4; 10 day, n = 4) displayed various degrees of gastric ulceration, compared to one S in the Nonshock group. Subsequent analysis found that the Shock group had a significantly higher incidence of ulceration than the Nonshock group ($X^2 = 9.1315$, df = 3).

Adrenal gland weights

A summary of the analysis of adrenal gland weights is shown in Table 6. It was found that the differences between Shock and Nonshock groups were significant. The Shock group was found to have heavier glands than their Nonshock counterparts, suggesting that the Shock animals were subjected to greater stress and were in a state of higher arousal during treatment. Moreover, the weights of the glands of the Shock group increased with the length of shock. This relationship is shown in Fig. 8. The 2 hr. Shock and Nonshock animals showed nearly equal weights, but the Nonshock weights dropped in the 5 day and 10 day groups, while the Shock weights continued

Table 6.

Summary of the analysis of variance of adrenal gland weights.

Source of variance	Mean square	df	F
Shock	982.72	1	22.31**
Length of treatment	12.35	2	<1
Length treatment x Shock	199.18	2	4.52*
(differences in linear trends)	(320.33)	(1)	(7.27)**
Error	44.04	66	

**p < .01
*p < .05

Fig. 8. Adrenal gland weights for the Shock and Nonshock groups over length of treatment.

to rise for the same periods. It is interesting to note that the Nonshock weights dropped during the 5 day and 10 day treatments, rather than remaining constant. This may reflect a decrease in bodily activity due to confinement in the treatment box. The differences in linear trends for the Shock and Nonshock groups were significant and accounted for 80% of the interaction variance.

Discussion

Briefly, the important findings were;

1) Differences in activity were not evident, though some trend differences between shocked and nonshocked animals did appear in the second session.

2) Differences in BRL trends were more apparent, with wide differences between both means and trends of shocked and nonshocked animals appearing in the first session, but disappearing in the second session; however, some differences did appear in the second session which were curvilinearly related to length of shock. In the first session and initially during the second, the shocked Ss showed a lower level of arousal as indicated by BRL.

3) No differences in defecation were apparent, though the increase in ulceration and adrenal weights in shocked animals corresponds to the type of treatment received by these animals.

Activity

The absence of differences in habituation of activity do not support the results obtained by Mackay (1963), Campbell & Candland (1961), nor Baron (1964), who all found effects of prior stimulation on activity. However, the results do support one of the findings of Montgomery & Monkman (1955), who found no decrease of activity when the shock was administered prior to the open field exposure. Other than the results offered by this study, no further substantial support for Montgomery & Monkman's findings has appeared.

Since this study used procedures nearly identical to those used by Mackay (1963), and was designed to expand the findings of that study, it is disturbing that the results of activity trends were not replicated by this study. In the earlier study, the differences in trends between shocked and nonshocked groups were clearly evident. The shocked groups showed faster deceleration of activity than the nonshocked animals, the rate of the deceleration varying non-monotonically with the length of shock. The absence of any differences in activity in the present study, coupled with clear differences in BRL, leaves the relationship between BRL and activity in doubt.

There are three obvious explanations which could be considered to account for the discrepancies between Mackay (1963) and the activity results of the present study. The first is that the earlier study used Sprague-Dawley albino rats, whereas Long-Evans hooded rats were used in the present study. It is possible that the differing rates of habituation found earlier by Mackay may be an effect specific to the strain. If so, then the interaction of constitutional and environmental factors must claim all the credit for the observed effect. Another possible factor is that the animals used in this study had received considerably more handling prior to the experiment than those used by Mackay.

The only other important change from the earlier Mackay study which might account for the differences was that a different open

field was used in the present study. Mackay (1963) used a round open field of unpainted galvanized metal 7 ft. in diameter with 30 in. walls. The open field used in the present study was a 4 ft. square of flat white painted wood, with walls 18 in. high and a white cloth screen hung above the walls. Another possibility is that the grid floor may have masked any potential differences, compared to the smooth white linoleum floor used in the previous study. After comparing mean activity of the groups used by Mackay (1963) and of the groups in the present study, it was found that the animals used in the present study were on the whole slightly less active. Considering the fact that the squares in the present open field were smaller and should have exaggerated the total activity, the grid floor seems to have impaired activity if it can be assumed that both strains are equally active (the total mean activity in the present study was 229 squares, compared to the 1963 total of 265). It seems more likely to attribute the difference in total activity between the two studies to differences in strains rather than to differences in flooring, and it is in fact possible that both factors interacted.

The last possibility is that there are simply no differences in activity under these conditions, and that the differences observed by Mackay (1963) were the result of some systematic bias in experimental procedure which produced a Type I error. It could be assumed that the activity data of the present study did not replicate the

data obtained earlier because of better controls in the present study or some other similar factor. In the light of the BRL data, this assumption should not be made too hastily. It is quite possible that better experimental techniques for measuring activity in a field (or perhaps more effective methods of inducing prolonged arousal) would in fact reveal differences in trends of activity corresponding to the BRL trends; a Type II error may have been responsible for the absence of differences.

Decrements in activity over sessions

The appearance of within session decrements fully confirmed the results of previous studies. The fact that activity decrements between sessions after a 5 day interval were also evident was somewhat unexpected. Previous studies, using intervals of up to 24 hr., suggested that the amount of decrement of intersession activity was inversely proportional to the length of intersession interval. With the interval of 5 days, according to previous results, the decrement should have nearly disappeared, but was in fact as large as the decrement reported by Snowdon, Bell, & Henderson after an interval of 24 hr. These results appear to indicate that the process responsible for the recovery of activity still seems affected after 5 days. Possibly the recovery of activity is accelerated up to say 24 hr., then tails off for much longer periods. It may require a much longer period than 5 days between sessions before a rat responds again to

to the situation with the same behavior patterns evident in the first session.

To summarize, one of the two aims of this study was to examine more thoroughly a variable which may be effective in producing differences in emotional reactivity as measured by activity; in this aim, the study did not succeed in showing that the variable was an effective one. Length of prior noxious stimulation, and even noxious stimulation per se, had little effect on activity. Differences in trends in the second session can be assumed to be the result of one group's activity decelerating linearly while the second group's activity decelerated curvilinearly.

BRL

The second aim was the establishment of a measure of arousal using a relatively novel technique; i.e., measuring BRL through a grid floor in an open field. This attempt was more successful. Prior shock produced clear differences both in levels and in habituation of arousal, though it was not clear whether the changes were permanent or more temporary. The design used in the present study allowed the examination of only one aspect of "permanence". It should be noted that when the word "permanent" was used earlier, it was referring to prolonged differences in ability to habituate over repeated presentations of one originally stressful situation. There were wide initial differences at the start of both the first and second sessions, but

differences in trends persisting over the whole session appeared only in the first session. In the second session, the differences in trends disappeared. The stimuli were obviously no longer novel, as each animal had already habituated to the novelty in the first session to a large extent. This finding fulfilled one of the purposes of the study; i.e., to determine if this characteristic of habituation to an initially novel situation was changed by stress, especially to see if the change persisted after an interval of 5 days. The BRL trends showed that the change in ability to habituate was present, but that it persisted only for the first session. To test the statement that the changes were permanent in that they occurred over a wide variety of novel situations, the design should incorporate a series of widely different novel situations.

BRL and auxiliary measures

Nevertheless, using only one novel situation, varying rates of habituation of arousal were observed until the novelty of the situation disappeared. The corresponding differences in weight, ulceration, and adrenal weights supported the differences occurring in the BRL data. The fact that the shocked animals showed higher resistance (and hence lower autonomic activity) in the open field in conjunction with the increased adrenal gland size and some ulceration indicates that these animals had undergone prolonged arousal but were now reacting to a situation of mild stress with decreased level of arousal. The control animals showed increasing levels of arousal

during the first session of the open field, indicating an entirely opposite trend in physiological arousal.

However, defecation, usually associated with emotional reactivity, showed no confirmation of the BRL, ulceration, or adrenal gland indications. It is also unfortunate that the initial weights of the various groups were not homogenous, but differences in activity or defecation did not occur despite the differences in size, nor did they occur when activity was expressed in terms of size.

Theoretical implications

The fact that the shocked animals showed higher resistance than the nonshocked animals does not support Malmo's hypothesis that prolonged arousal would lead to chronic anxiety. The data does in fact suggest more rapid habituation in the shocked animals, as indicated by the BRL trends. Generally, the shocked animals showed lower base levels of arousal at the beginning of each session, and in addition seemed capable of returning to that base level at a faster rate than the nonshocked group. For instance, in the first session, while the nonshocked group did not start returning to their original arousal level until the final 3 min. of the session, the shocked animals had reached a peak of arousal and started returning to their original level of arousal after the first 3 min. of the session. This phenomenon did not reappear when the situation was repeated; in the second session, the shocked animals continued to show a persistent lower

initial level of arousal, but both shocked and nonshocked groups tended to show an identical rate of habituation. The lower initial level of arousal, or base level, seems to persist over repeated exposures of a novel situation; the differing rates of habituation were confined only to the first session and did not appear to be as persistent.

Though the explanation for these results at this time seems fairly remote, the results themselves support Levine and Denenberg's proposals that prior stimulation results in a decrease of emotional reactivity. A possible theoretical explanation for these results may lie in the process of habituation, or in the establishment of an adaptation level. Each animal may gradually habituate to continued administration of noxious stimulation so that when subsequent stressful stimuli are presented, the animal may react to the stimuli in the context of the previously administered stress and behave as if it were of a minor nature. This explanation relies on a habituating mechanism, and it is possible that the explanation holds true only up to certain intensities or durations of noxious stimulation; beyond these points, Malmo's hypothesis could achieve validity. It is possible that the length of treatment used in this study was not sufficient to reach these critical points, but on the basis of previous results it has to be assumed that the treatment extended long enough to reach this hypothetical critical point. In addition to the three lengths of treatment used in the present study, Mackay (1963) used

a fourth group, one which was shocked for 30 days. Since 8 of the 10 rats in that group died, and 2 of the 10 rats in the 10 day group died, it is fairly safe to assume that the critical length of treatment was very close to 10 days.

At any rate, the conclusions reached tentatively in the present study (tentative in the absence of activity differences) somewhat resemble the conclusions drawn by Mackay in 1963. The decrements of activity observed then, if one can extrapolate the results of the present study, seem to reflect a process of accelerated habituation to a novel situation. This statement must be qualified by the fact that in the second session, BRL clearly decreased as the length of treatment increased. Malmo's hypothesis receives some support from this evidence, though the absence of this phenomenon in the first session makes the validity of this finding somewhat questionable.

Conclusions

The overall conclusions are these: no clear relationship between open field activity and BRL in the open field could be established; moreover, there is no evidence to confirm earlier findings that prior noxious stimulation produces changes in emotional reactivity as measured by activity. From this point of view, the results did not help clarify the conclusions of previous studies dealing with the relations between emotionality or fearfulness and open field activity and defecation. The ambiguity surrounding activity as a

measure of reactivity has not been resolved by this study. Nevertheless, the validity of BRL as an indicant of changes in arousal produced by previous noxious stimulation was established. Prolonged noxious stimulation appears to produce a fairly persistent decrement in base level of arousal; furthermore, lability of arousal seems to be increased by such stimulation. Not only is base level of arousal lower, but returns to the base level of arousal are accomplished at an accelerated rate after exposure to a mildly stressful situation. Finally, decrements in activity were observed both within sessions and between sessions, confirming previous results.

Summary

The purpose of this study was to establish a relationship between open field activity and a physiological measure of arousal (Basal Resistance Level) to clarify the effects of prior noxious stimulation on habituation of arousal to a mildly stressful situation, the open field.

One group of rats received varying periods of unavoidable shock; the second group received identical treatment except for shock. Each rat was then observed in an open field for two 15 min. sessions and activity, BRL, and defecation were measured. Post-mortem gastric ulceration and adrenal gland weights were also noted.

No major differences in activity were evident. No relationship between activity and BRL could therefore be established. The shocked animals showed lower initial arousal in each session than the nonshocked animals, and they also demonstrated faster habituation to the open field, but only in the first session. Length of treatment produced BRL differences in the second session, and decrements of activity were observed both within and between sessions. The treatment did not produce any differences in defecation. The validity of BRL as a measure of arousal was considered to be still indefinite in the absence of any behavioral correlates, but the technique used in its observation in the open field was clearly established for future use.

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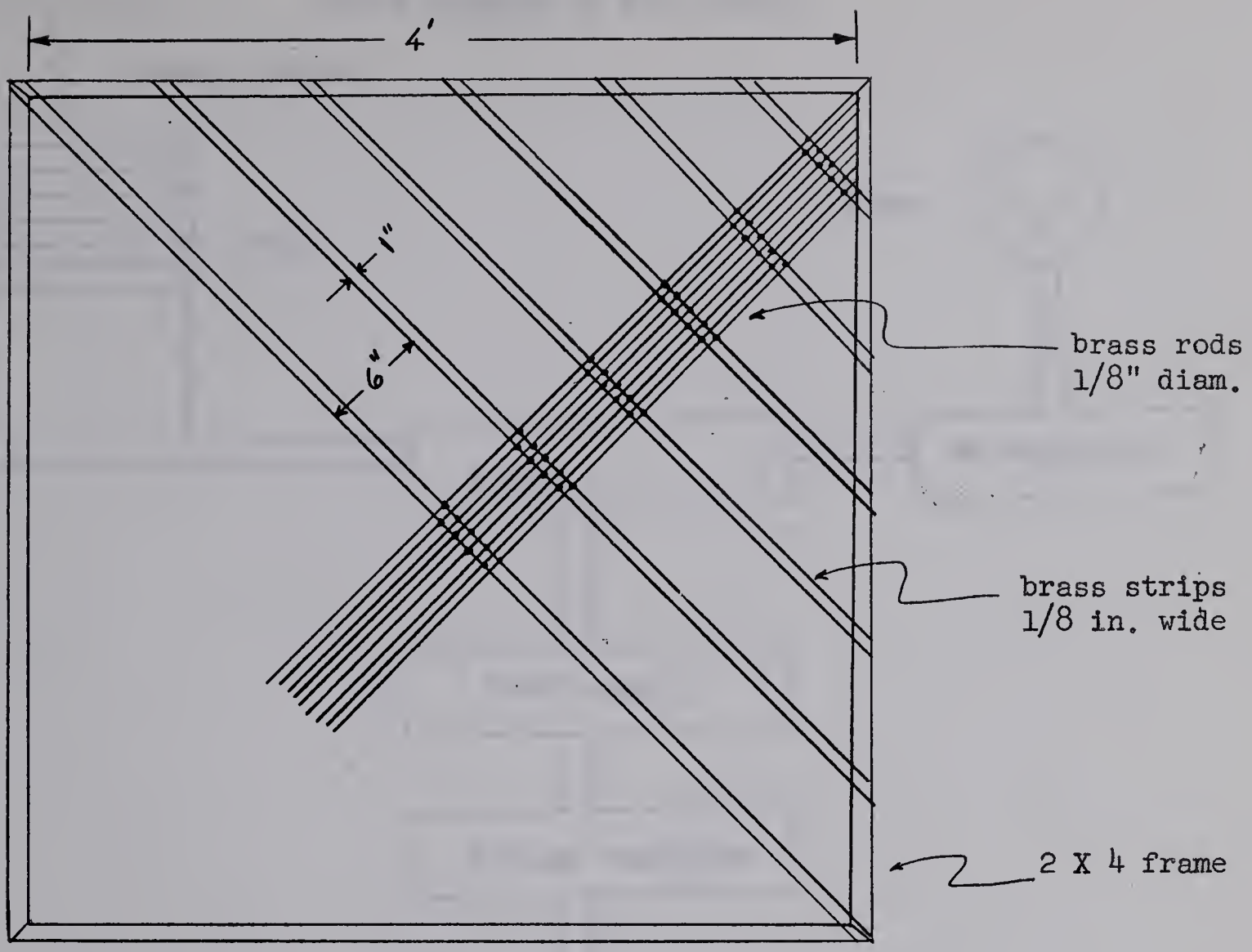
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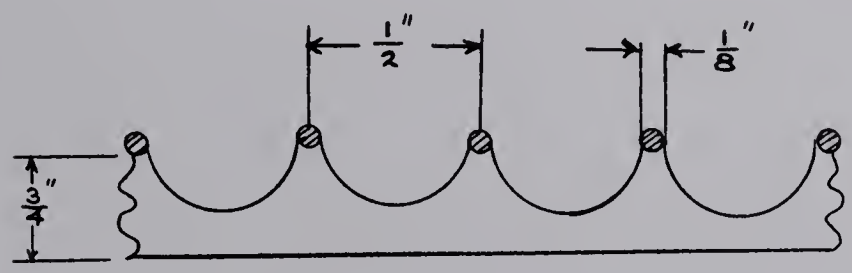
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Appendix A



Top view

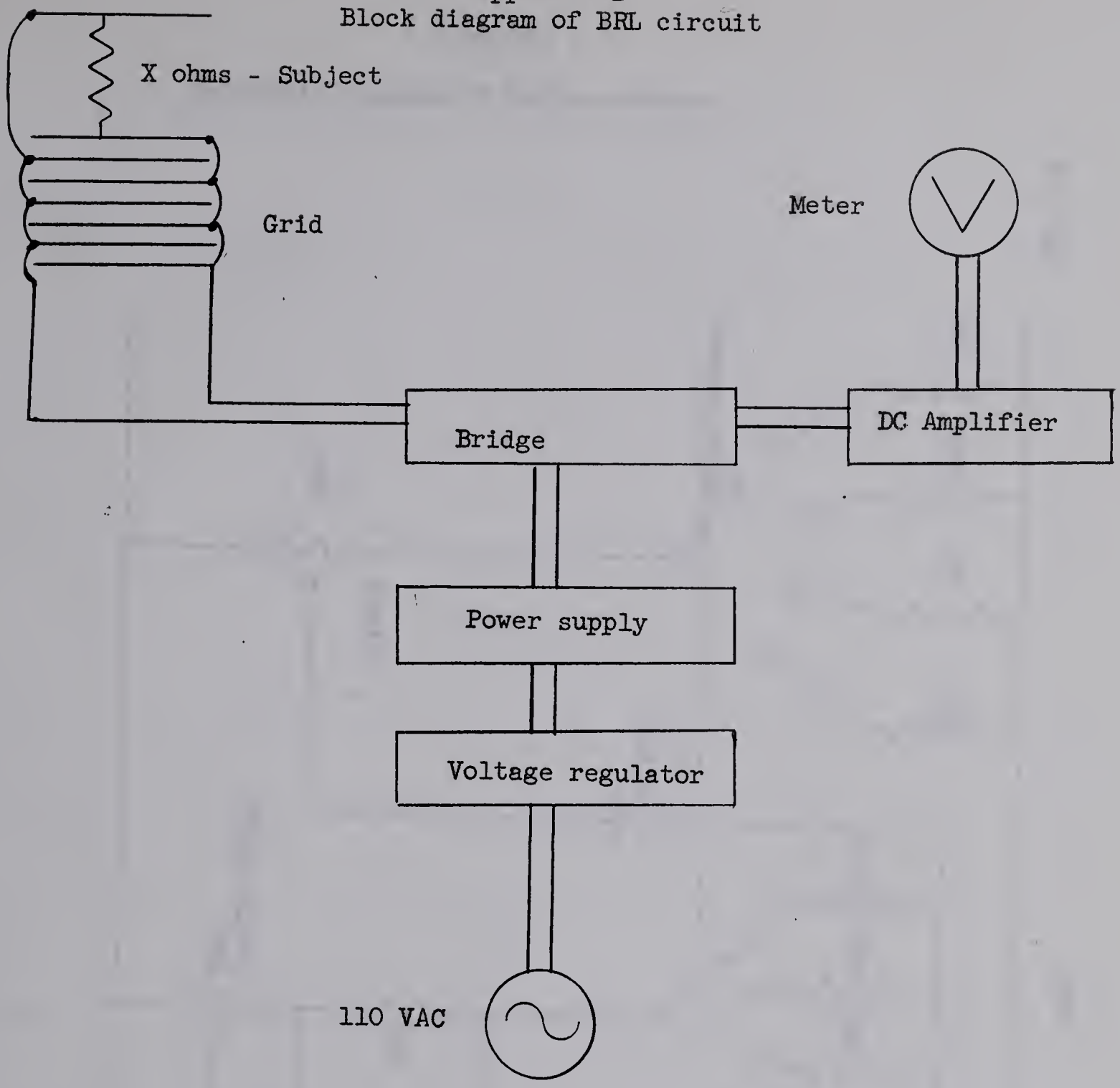


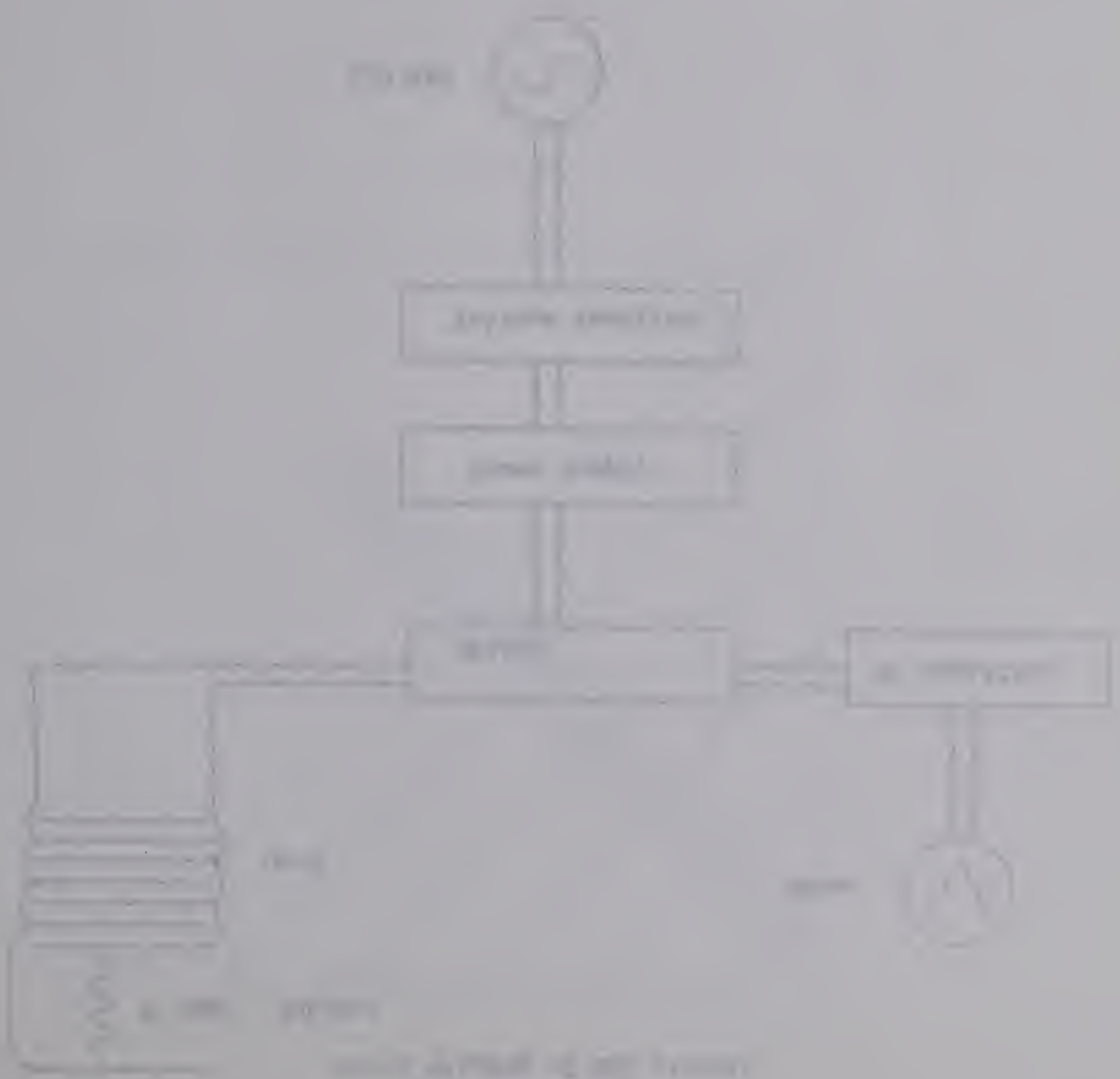
Side view of brass strip





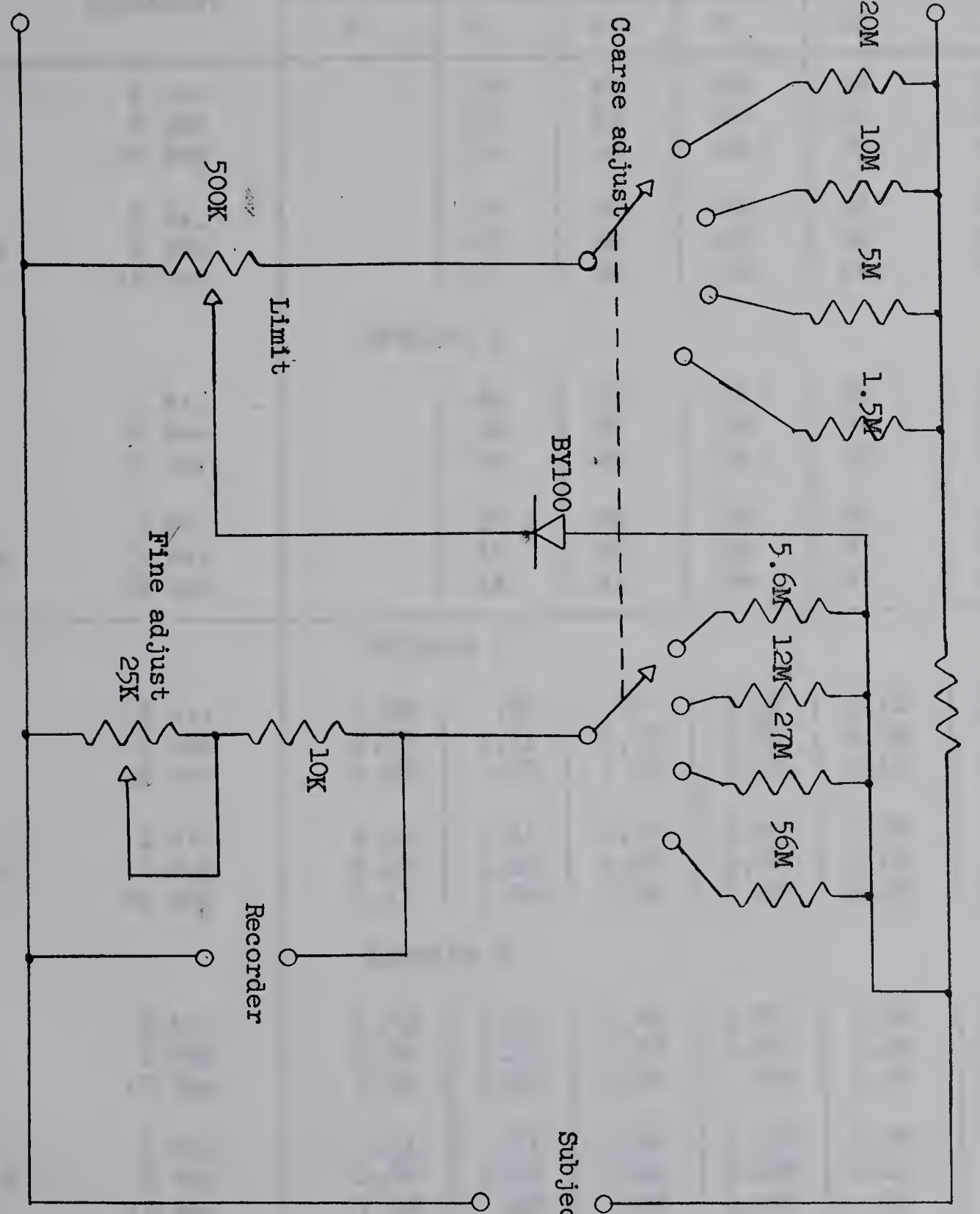
Appendix B
Block diagram of BRL circuit





Appendix C

Schematic diagram of bridge circuit





Appendix D

Means of activity and BRL for all groups.

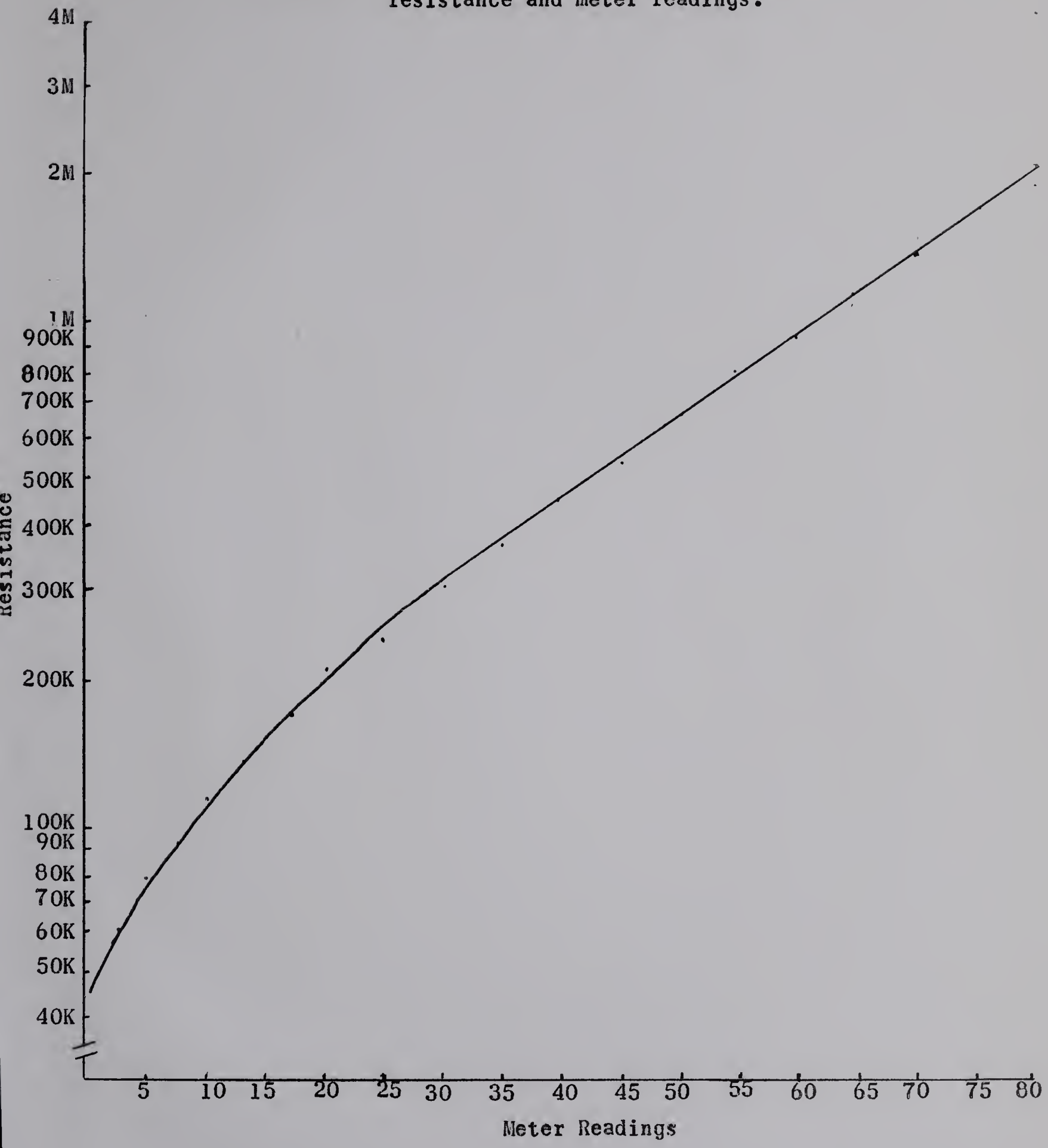
ACTIVITY

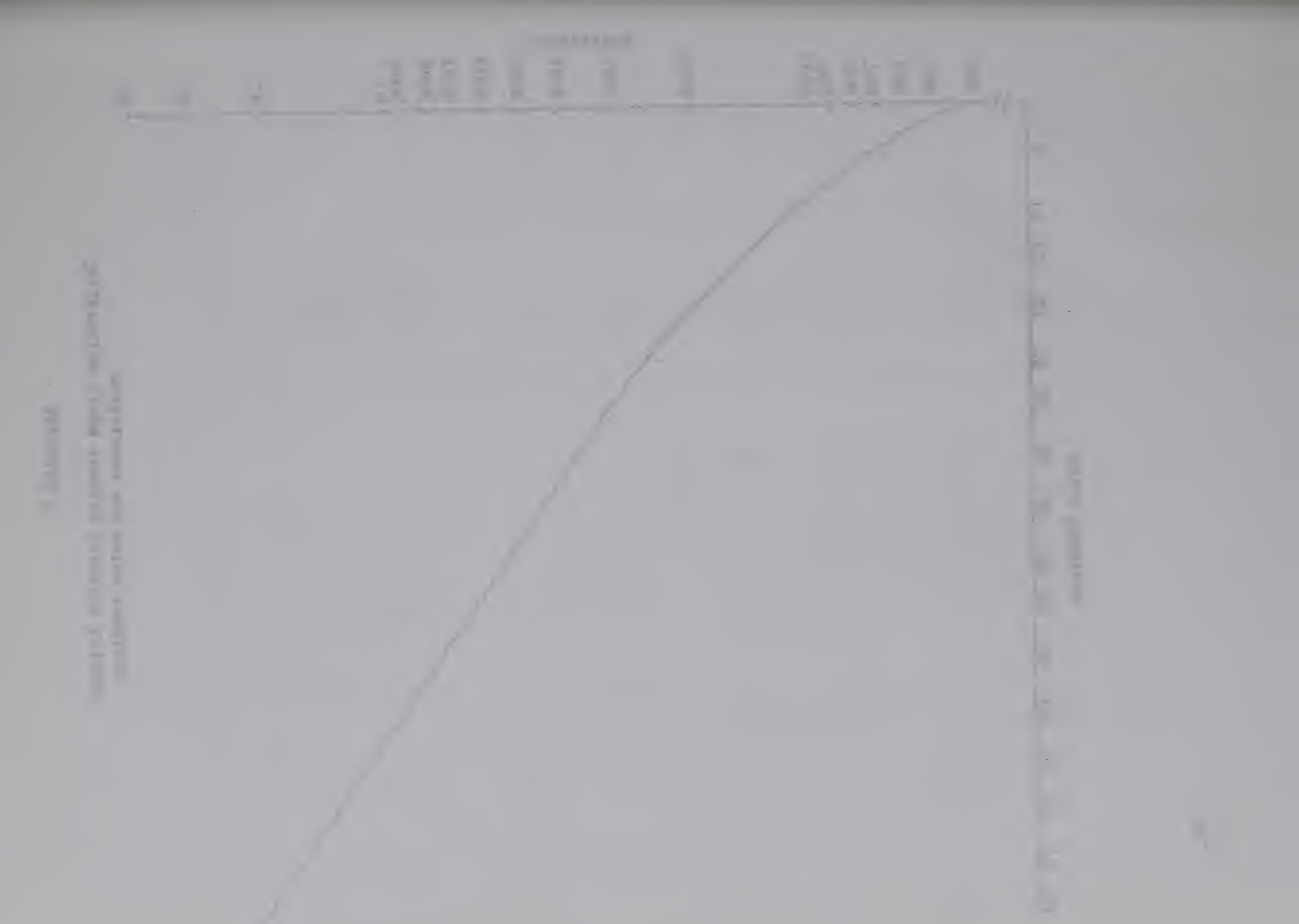
SESSION I

Condition	Length of treatment	Minutes in open field					
		0	3	6	9	12	15
Shock	2 hr.		54	45	38	38	33
	5 day		59	55	49	41	34
	10 day		56	44	43	36	28
Nonshock	2 hr.		59	52	54	43	33
	5 day		61	58	48	46	42
	10 day		62	48	46	39	31
		SESSION 2					
Shock	2 hr.		48	44	37	38	35
	5 day		54	39	39	34	29
	10 day		50	33	26	26	29
Nonshock	2 hr.		39	38	37	36	34
	5 day		44	37	38	34	27
	10 day		44	31	36	31	29
BRL		SESSION 1					
Shock	2 hr.	1.36	.98	.97	1.14	1.15	1.16
	5 day	1.37	1.31	1.35	1.20	1.38	1.28
	10 day	1.40	.92	1.12	1.14	1.12	1.22
Nonshock	2 hr.	1.23	1.11	1.00	1.05	.87	.96
	5 day	1.09	1.20	1.09	1.08	1.01	1.08
	10 day	1.17	1.09	1.08	1.05	1.05	1.15
		SESSION 2					
Shock	2 hr.	1.45	1.31	1.46	1.37	1.36	1.22
	5 day	1.51	1.12	1.12	1.06	1.08	1.10
	10 day	1.23	1.02	1.03	.90	1.06	1.00
Nonshock	2 hr.	1.21	.91	1.04	1.04	1.09	1.03
	5 day	1.53	1.30	1.25	1.35	1.21	1.28
	10 day	1.04	.85	.94	1.12	.96	1.20

Appendix E

Calibration graph showing relation between resistance and meter readings.





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